



THE LITHOSTRATIGRAPHIC UNITS OF THE AUSTRIAN STRATIGRAPHIC CHART  
2004 (SEDIMENTARY SUCCESSIONS)  
WERNER E. PILLER [ED.]

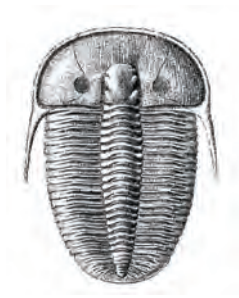
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Authors:  
Bernhard Hubmann [Coordinator] (Graz),  
Fritz Ebner (Leoben), Annalisa Ferretti (Modena),  
Erika Kido (Graz), Karl Krainer (Innsbruck),  
Franz Neubauer (Salzburg),  
Hans Peter Schönlaub (Kötschach-Mauthen)  
& Thomas J. Suttner (Graz).



Geologische Bundesanstalt

**Address of editor:**

Werner E. Piller  
University of Graz  
Institute for Earth Sciences  
Heinrichstraße 26, A-8010 Graz, Austria  
werner.piller@uni-graz.at

**Addresses of authors:**

Bernhard Hubmann  
University of Graz  
Institute for Earth Sciences  
Heinrichstraße 26, A-8010 Graz, Austria  
bernhard.hubmann@uni-graz.at

Fritz Ebner  
University of Leoben  
Department of Geosciences/Geology and Economic Geology  
Peter-Tunner-Straße 5, A-8700 Leoben, Austria  
fritz.ebner@unileoben.ac.at

Annalisa Ferretti  
Università degli Studi di Modena e Reggio Emilia  
Dipartimento di Scienze della Terra  
Largo S. Eufemia 19, I-41121 Modena, Italy  
ferretti@unimore.it

Karl Krainer  
University of Innsbruck  
Institute of Geology and Paleontology  
Innrain 52, A-6020 Innsbruck, Austria  
karl.krainer@uibk.ac.at

Franz Neubauer  
University of Salzburg  
Department of Geography and Geology  
Hellbrunnerstraße 34, A-5020 Salzburg, Austria  
franz.neubauer@sbg.ac.at

Hans Peter Schönlaub  
Past Director, Geological Survey of Austria  
Kötschach 350, A-9640 Kötschach-Mauthen, Austria;  
hp.schoenlaub@aon.at

Erika Kido, Thomas J. Suttner  
University of Graz  
Institute for Earth Sciences  
Heinrichstraße 26, A-8010 Graz, Austria  
erika.kido@uni-graz.at; thomas.suttner@uni-graz.at

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## The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions)

WERNER E. PILLER

In the late 1990's the Austrian Stratigraphic Commission (ASC) started to evaluate the common lithostratigraphic units in Austria with the intention to formalize those which are in accordance with the German/Austrian "Recommendations (guideline) to the use of stratigraphic nomenclature" (STEININGER & PILLER, 1999) and to redefine those which are not. After a series of workshops including also several field trips it became clear that this goal cannot be reached within the next decades. Therefore, in 2002 the ASC decided to compile a chart in which most lithostratigraphic units in use should be depicted in a modern chronostratigraphic/geochronologic frame. During general discussions on the content of the chart it turned out that the current state of knowledge does not allow to include crystalline rocks and, therefore, the content will clearly focus on sedimentary units (also including those with a low grade metamorphism).

At approximately the same time, but slightly ahead, the German Stratigraphic Commission compiled a stratigraphic chart of Germany which was published in 2002 (GERMAN STRATIGRAPHIC COMMISSION, 2002a). To make a comparison between the German and the Austrian charts easier the ASC agreed to use a format for the Austrian chart similar to the German one. The similarity concerns mostly general layout and colour/signature for the rock (facies) types (so far applicable). The chronostratigraphic/geochronologic base for the two charts, however, was different. While the German table is based on a combination and integration of international and national data (GERMAN STRATIGRAPHIC COMMISSION, 2002b), which ended up in a unique time scale, the Austrian chart consistently used the data of "A Geologic Time Scale 2004" (GRADSTEIN et al., 2004) as a reference. The German table also includes a variety of regional stages, characteristics and peculiarities, e.g., for the Paleozoic, Triassic, Jurassic, and Cenozoic. In the Austrian chart only for the Oligocene – Pliocene the regional stages of the Central Paratethys have been added to the international chronostratigraphic classification. The chart is, in fact, a regional (Austrian) lithostratigraphic compilation put into the international chronostratigraphic/geochronologic framework of 2004.

After less than 2 years of intense re-evaluation, discussion and compilation the Austrian Stratigraphic Chart has been finished and published in 2004 (PILLER et al., 2004) including about 660 lithostratigraphic units. The number of the units is not complete due to space. So far possible, the organization of the chart intended to depict these lithostratigraphic units in a geographical arrangement of tectonic units within Austrian territory from west to east.

The Paleozoic and Triassic successions have been arranged in a widely consistent manner and time scale. Due to the basic change in the geodynamic evolution of the Eastern Alps a major break in the chart occurs at the Triassic/Jurassic boundary (expressed by a bold horizontal line in the chart). Another basic reorganisation occurs around the Eocene/Oligocene boundary and within the Pleistocene. Due to increasing time resolution the numerical scale changes at the Cretaceous/Paleogene and the Paleogene/Neogene boundaries as well as within the Pleistocene (at 1.01 Ma). A deviant representation has been applied to the Quaternary. Besides few exceptions (e.g., Höttinger Breckzie [Hötting Breccia]) no lithostratigraphic units have been implemented but only sediment bodies and lithologies related to glacial phenomena (e.g., moraines, terraces) were included. This follows the discussion and recommendation in PILLER et al. (2003). To underscore this deviation and point at the glacial events the oxygen-isotope-based temperature curve after RAYMO (1997) has been added for this time interval.

A stratigraphic chart, however, requires explanations and a description of the content. For such a description a variety of possibilities exists including very short notes like for the Stratigraphic Table of Germany 2002 (GERMAN STRATIGRAPHIC COMMISSION, 2002b) or its extended explanatory notes (MENNING & STEININGER, 2005). Since a comprehensive description of the lithostratigraphic units of Austria was published within the Lexique Stratigraphique International and dates back already to 1962 (KÜHN, 1962) the urgent need for an updated and enhanced version was evident. Strong pressure accrued also from the geoscientific community itself. Therefore, the ASC agreed to describe the lithostratigraphic units of the Austrian Stratigraphic Chart 2004 in a detailed way. Although the Austrian Stratigraphic Chart 2004 is in German language it was decided to publish the explanatory notes in English to provide better international access. During several meetings the concept for these descriptions was finalized in 2008. It was agreed that only those lithostratigraphic units have to be described which are also represented in the Austrian Stratigraphic Chart 2004. Exceptions are only necessary where single formations could not be depicted in the Austrian Stratigraphic Chart 2004 due to space limit (e.g., "Eggenburg Group" with several formations in the Burdigalian). Describing new units or formalizing existing units has been excluded. The arrangement of the subchapters should be in accordance with the chart, generally from older to younger and from left to right. Several lithostratigraphic units, however, occur repeatedly in different positions

in the chart and many of them cross chronostratigraphic boundaries. These units will be described only once with respective cross references. For each chapter a comprehensive introductory text has to be presented addressing general aspects.

The description of the lithostratigraphic units has to follow a fixed scheme. The name of the unit has to appear in identical wording and spelling as in the chart followed by an English version of this name. The authorship for the description of each unit has to be explicitly stated. Within the text the English version of unit names has to be used. A fixed number and sequence of characteristics for each lithostratigraphic unit has been developed following the recommendations of STEININGER & PILLER (1999) and the first applications by RASSER & PILLER (1999). The final version of this concept has been developed by Hans-Georg Krenmayr (Geological Survey of Austria) and Michael Wagreich (University of Vienna) together with the author. This list for each unit includes the following characteristics: Validity, Type area, Type section, Reference section(s), Remarks (concerning the type area, type section and reference sections), Derivation of name, Synonyms, Lithology, Fossils, Origin, Facies, Chronostratigraphic age, Biostratigraphy, Thickness, Lithostratigraphically higher rank unit, Lithostratigraphic subdivision, Underlying units, Overlying

units, Lateral units, Geographic distribution, Remarks and Complementary references. For the locations of Type area, Type section and Reference section(s) international geographical coordinates (latitude, longitude) have to be provided. For map references both the international UTM-system and the old Austrian BMN-system with numbers and names of map-sheets have to be indicated since the numbers and names do not coincide in both systems.

Originally, a single volume for the entire explanatory notes was planned. However, during compilation it became clear that for some time intervals compilation was faster than for others and also the volume would become bulky when all c. 660 lithostratigraphic units will be included. Fortunately, the Geological Survey of Austria agreed to split the explanatory notes into three volumes according to the three era(them)s – Paleozoic, Mesozoic and Cenozoic – and to publish each of them as a separate volume in the “Abhandlungen der Geologischen Bundesanstalt”. In addition, the respective part of the Austrian Stratigraphic Chart 2004 will be added to each volume as an attachment. This extracted part is identical with those in the chart 2004 but the unit names are in English according to the names in the description. Only formal errors (such as wrong calculations of numerical ages or some typographical errors) have been corrected in the added English version.

## Acknowledgements

I would like to express my appreciation to all authors involved in the compilation of the Austrian Stratigraphic Chart 2004. All of them did an excellent job and made publishing in a very short period possible. Furthermore, I would like to thank all these authors (and some additional ones) for doing this tedious and (at least sometimes) boring job. They worked through a tremendous amount of literature, sometimes highly inappropriate from a stratigraphic point of view, and accomplished the descriptions of the lithostratigraphic units – they all get my highest esteem! At this point I want to thank in particular the coordinators of the main time intervals: Bernhard Hubmann (Paleozoic), Gerhard W. Mandl (Triassic), Gerhard W. Mandl

and Leopold Krystyn (Jurassic), Michael Wagreich (Cretaceous), Reinhard Roetzel (Neogene), and Dirk van Husen (Quaternary). Special thanks go to Hans-Georg Krenmayr who was strongly involved in the conception for the descriptions and to Thomas Hofmann and Christoph Janda (all Geological Survey of Austria) for their constructive cooperation and patience during the final steps of layout and printing.

The Austrian Academy of Sciences funded editing and printing of the Austrian Stratigraphic Chart 2004 via the Commission for the Palaeontological and Stratigraphical Research of Austria.

## Remark on the 2<sup>nd</sup> edition of “The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions). Vol. I: The Paleozoic Era(them)”

The 1<sup>st</sup> edition of “The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions). Vol. I: The Paleozoic Era(them)” has been published in 2013 in Abhandlungen der Geologischen Bundesanstalt, Band 66. Unfortunately one of the co-authors, Kathleen Histon, wanted her co-authorship eliminated and insis-

ted to stop further delivery of this volume. This incident evoked publication of a 2<sup>nd</sup> edition. In this 2<sup>nd</sup> edition, published 2014, the entire content of the volume is identical with the 1<sup>st</sup> edition (2013), only the name of Kathleen Histon as a co-author has been obliterated as requested.

Werner E. Piller, editor  
Graz, January 2014

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Supplement: Austrian Stratigraphic Chart 2004 – Paleozoic



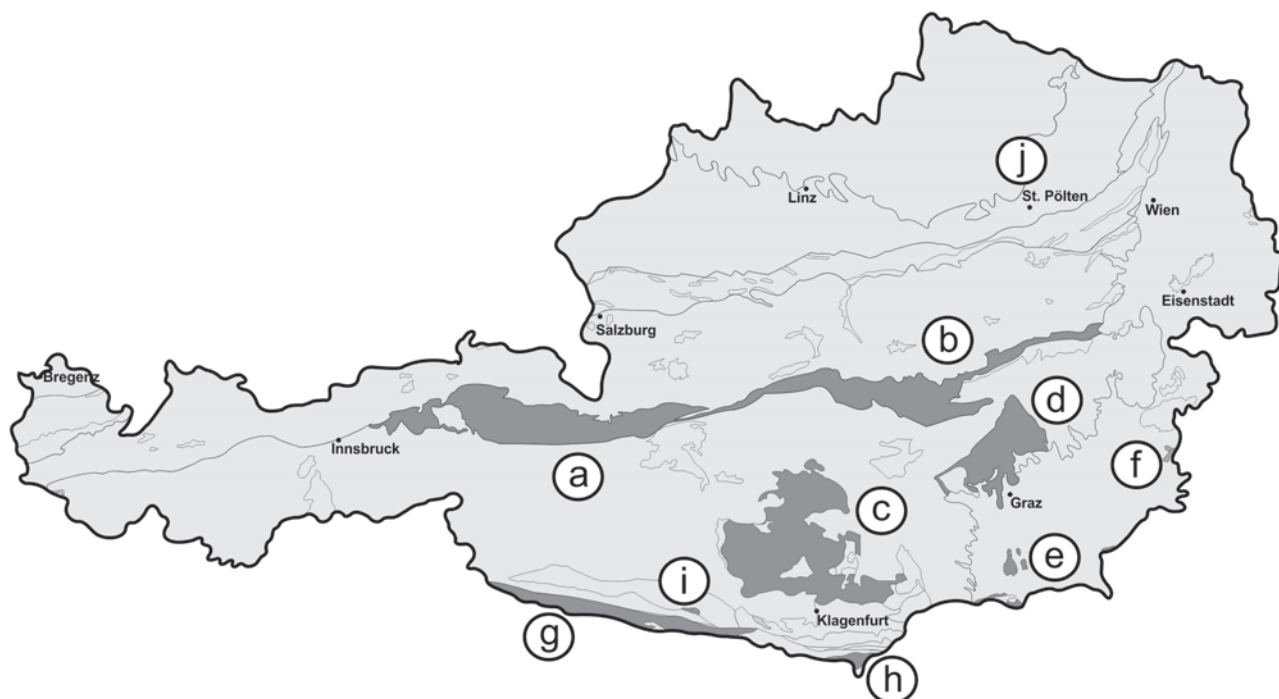
## Introduction

Profound studies of Paleozoic successions within Austria's territory go back to an amazingly long period of more than 150 years of research history. To the end of the first half of the 19<sup>th</sup> century all systems of the Paleozoic erathem (with the exception of the Ordovician) had been established thus enabling a systematic recognition and correlation of time-equivalent strata over different countries. As early as in 1843 Franz UNGER, paleobotanist at the Joanneum in Graz, recognized Devonian rocks (only four years after establishment of the system!) in Austria. A few years later, particularly during comprehensive geological mapping by the Austrian Geological Survey ("Geologische Reichsanstalt"; after the breakdown of the Austrian-Hungarian Monarchy the "Geologische Bundesanstalt"), Silurian successions were recognized by Franz HAUER in 1847. Permian rocks containing fusulinids were identified by Guido STACHE in 1872 and Ordovician strata, also by STACHE, in 1884. The Carboniferous ("age of carbonaceous limestone") was for a long time well-known in Alpine geology, however, for several decades this system remained a vast bin for unidentified Paleozoic rocks.

Since lithostratigraphic units are the basic entities of geological maps specific names were assigned to distinct lithological sequences already during early periods of geologic surveying. Initially naming was very general and frequently used in a dual sense to combine lithological

features with (relative) age implications (e.g., "Übergangskalk" or transitional rocks, placed between the "uranfängliche Gebirge" [= basement rocks containing no fossils] and the "Flötz-Gebirge" [= stratified and low-dipping rocks often holding fossils] in the sense of Abraham Gottlob WERNER's stratigraphy). Following the fundamental ideas of Hollis Dow HEDBERG during the mid-1970s lithostratigraphic units more and more were based on their observable physical features only and not on their inferred age. Since 1999 a "Recommendation (guideline) to the handling of the stratigraphic nomenclature" (STEININGER & PILLER, 1999) exists which (at least) should regulate (new) designations. However, a synoptical compilation of lithostratigraphical units ("formations") as given herein, uncovers still a large number of the lithostratigraphical terms to be invalid.

Areas within Austria's borderlines exhibiting anchizonal to lower greenschist metamorphosed Paleozoic successions are remnants which were dismembered during Variscan and Alpine orogeneses and incorporated into the complicated Alpine nappe system. Today these Paleozoic areas are irregularly distributed (Text-Fig. 1). Within the Alpine mountain belt sequences belong to the "Upper Austroalpine Nappe System" (i.e., the Western Greywacke Zone (Tyrol, Salzburg), Eastern Greywacke Zone (Styria and Lower Austria), the Carboniferous of Nötsch, the Gurktal



Text-Fig. 1. Regions of anchizonal to lower greenschist metamorphosed Paleozoic strata in Austria. (a) Western Greywacke Zone; (b) Eastern Greywacke Zone; (c) Gurktal Nappe System; (d) Graz Paleozoic; (e) Remschnigg and Sausal areas; (f) Southern Burgenland; (g) Carnic Alps; (h) Karavanke Mountains; (i) Carboniferous of Nötsch; (j) Lower Paleozoic of Zöbing.

Nappe System, the Graz Paleozoic and some isolated outcrops in southern Styria (Remschnigg/Sausal) and Burgenland as well as the Southern Alpine System (Carnic Alps and the Karavanke Mountains; Southern Carinthia). Outside the Alpine region an isolated upper Paleozoic (Carboniferous, Permian) occurrence is known resting on crystalline units of the Bohemian Massif.

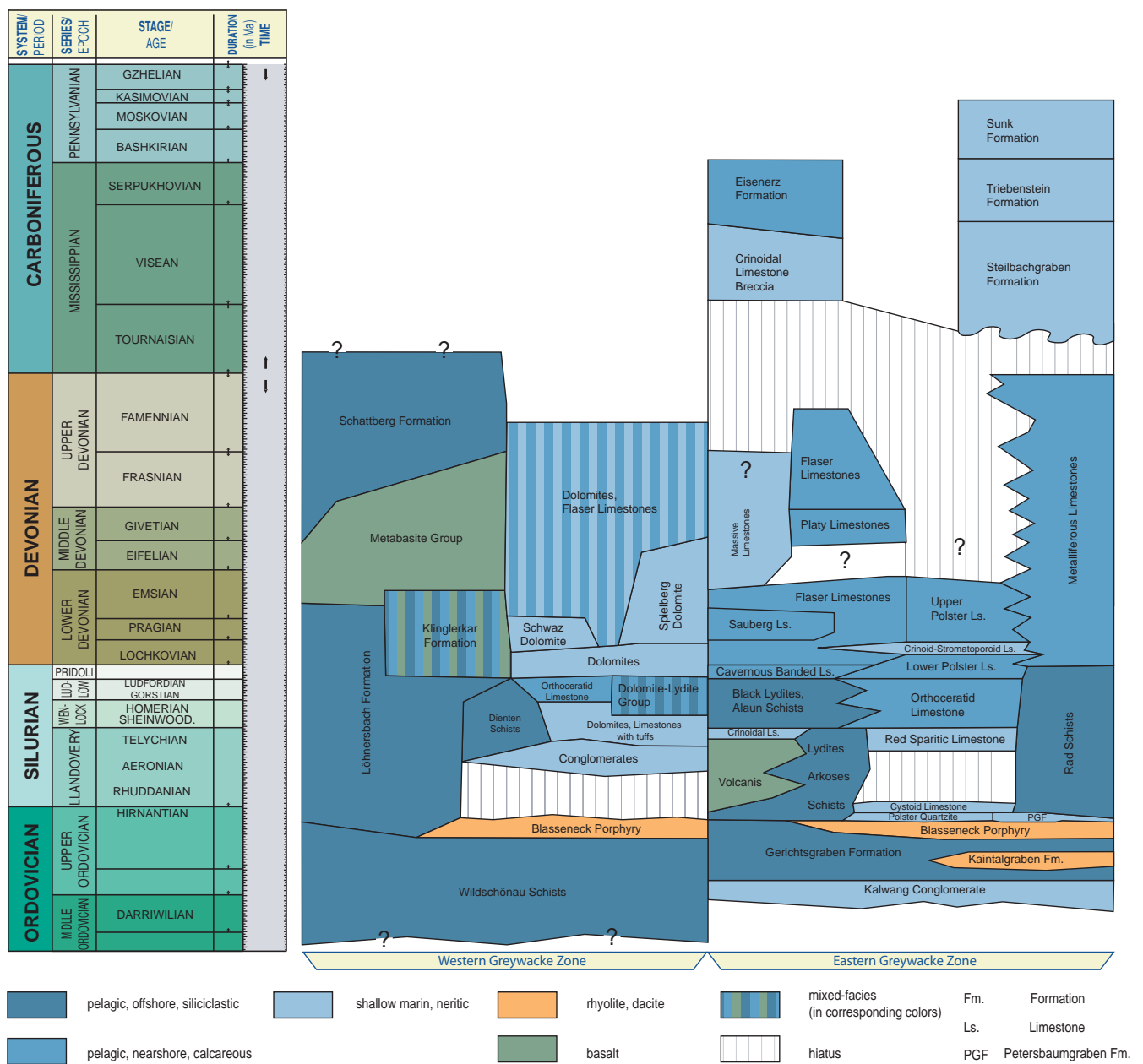
All Paleozoic occurrences together constitute a surface ratio of less than 10 % of the Austrian territory. More than 40 % of the Paleozoic area is covered by the Greywacke Zone, one-third by the Gurktal Nappe System; the Graz Paleozoic takes little more than 10 % and the Carnic Alps less than 10 % of the Paleozoic area.

Geologic units do not stop at national borders. Therefore a number of Italian colleagues kindly co-operated describ-

ing lithostratigraphic units of the Carnic Alps which are outcropping on both sides of the Austrian-Italian border.

In the following 191 lithostratigraphic units are briefly described. Some typological errors of lithostratigraphic names and graphic mistakes concerning stratigraphic ranges of formations as illustrated in the ASC 2004 had to be corrected. The Greywacke Zone featured too many inconsistencies and made a revision necessary which resulted in a differing conceptual base for the lithostratigraphic arrangement (Text-Fig. 2). The reader interested in the Greywacke Zone therefore is kindly requested to use the new graphic chart. Note also that explanatory remarks of the Greywacke Zone are only provided on lithostratigraphic units which are illustrated in the new concept (Text-Fig. 2).

Bernhard Hubmann



Text-Fig. 2. Revised lithostratigraphic chart of the Western and Eastern Greywacke Zone.



# The Paleozoic Era(them)

B. HUBMANN, F. EBNER, A. FERRETTI, E. KIDO, K. KRÄINER, F. NEUBAUER, H.P. SCHÖNLAUB & T.J. SUTTNER

## Grauwackenzone / Greywacke Zone

The Greywacke Zone (GWZ) in the Eastern Alps is part of the Upper Austroalpine Nappe System (TOLLMANN, 1977; SCHMID et al., 2004). It is subdivided into the Western Greywacke Zone (W-GWZ) in Tyrol and Salzburg and the Eastern Greywacke Zone (E-GWZ) extending from North-western Styria to areas around Gloggnitz in Lower Austria in the East. In addition to Alpine thrust tectonics the GWZ includes Variscan nappe structures. In total, the stratigraphic sequences cover Middle Ordovician to Moskovian (Westfalian) ages. The very low to low grade metamorphic overprint is of Alpine Cretaceous age (COLINS et al., 1980; RANTITSCH et al., 2004; RANTITSCH & JUDIK, 2009).

Major parts of the GWZ (W-GWZ and Noric Nappe of E-GWZ) belonged to the Noric Composite Terrane (FRISCH & NEUBAUER, 1989). This was part of the Paleozoic European Hun Terranes which have been separated from Gondwana during early Paleozoic times and accreted after a mid-Paleozoic drift stage during the early Carboniferous Variscan orogeny at the European continental margin

(FRISCH & NEUBAUER, 1989; NEUBAUER et al., 1998; STAMPF, 2001; RAUMER et al., 2003; EBNER et al., 2007, 2008). Contrarily, the Carboniferous of the Veitsch Nappe in the E-GWZ was formed in a marine molasse like foredeep in front of the already formed internal Variscan Median Crystalline Zone (FLÜGEL, 1977, 1990). Therefore, the Carboniferous of the Veitsch Nappe avoids any Variscan tectonic deformation and metamorphism (RATSCHBACHER, 1984, 1987; EBNER et al., 2008).

In the ASC 2004 (PILLER et al., 2004) the column of the GWZ is subdivided from left to the right into the W-GWZ and the E-GWZ. Previous summaries on the stratigraphy of the GWZ or major parts of it are published in FLÜGEL (1964, 1970), FLÜGEL & SCHÖNLAUB (1972a), TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989, 1991), KRÄINER (1993a), and SCHÖNLAUB & HEINISCH (1993). Due to some errors in the ASC 2004 a new conceptual base for the lithostratigraphic arrangement of the Western and Eastern Greywacke Zone is provided in Text-Fig. 2.

### W-Grauwackenzone / Western Greywacke Zone (W-GWZ)

The stratigraphic frame documented in the ASC 2004 (PILLER et al., 2004) was established mainly by the working group around H. MOSTLER (University of Innsbruck) in the early 1960s–1970s and by the group of H. HEINISCH (University of Munich) in the Kitzbühel – Saalbach area during the 1980s. MOSTLER (1973) recognized Variscan thrust tectonics resulting in four nappes (Alpbach, Hohe Salve, Jochberg and Langeck unit). The group of HEINISCH elaborated two distinct Paleozoic facies realms, presently occurring in two Alpine nappes (Wildseeloder and Glemmtal unit) separated by a cataclastic shear/thrust zone (Hochhörndler Schuppenzone; Silurian dolomite) (HEINISCH, 1988; SCHÖNLAUB & HEINISCH, 1993). However, the paleogeographic relationship of these two facies realms is not known although they occur presently in a relatively narrow area W of Zell am See (HEINISCH, 1986, 1988; HEINISCH et al., 1988; SCHLAEGEL-BLAUT, 1990). The sequence of the Wildseeloder Unit starts with thick Late Ordovician porphyroids followed after an early Silurian erosional gap by pelagic and shallow water carbonate environments up to the early Famennian. The Glemmtal Unit is dominated by siliciclastics which include thin layers of porphyroid materials, a late Silurian–Early Devonian basinal carbonate/lydite environment and a thick Devonian basic magmatic complex (HEINISCH, 1988; SCHLAEGEL-BLAUT, 1990; SCHÖNLAUB & HEINISCH, 1993). The lithostratigraphic subdivisions in the ASC 2004 (PILLER et al., 2004) are mostly informal working terms which correspond with the units/terms used by SCHÖNLAUB (1979: Tab. 3).

#### *Siliciclastic facies (partim Glemmtal Unit in the Kitzbüheler Alpen)*

#### **Wildschönauer-Schiefer / Wildschönau Schists**

FRITZ EBNER

**Validity:** Invalid; lithostratigraphic unit used since CATHREIN (1877) in terms of a formation but not formalized. Well characterized by MOSTLER (1968).

**Type area:** W-GWZ; around Wildschönau (N 47°25'28" / E 12°02'35"), ÖK50-UTM, map sheet 3213 Kufstein (ÖK50-BMN, map sheet 120 Wörgl).

**Type section:** Not selected.

**Reference section(s):** -

**Derivation of name:** After the area of Wildschönau, ÖK50-UTM, map sheet 3213 Kufstein (ÖK50-BMN, map sheet 120 Wörgl).

**Synonyms:** "Untere Grauwackenschiefer" (OHNESORGE, 1909); "Tiefere Wildschönauer Schiefer" (MOSTLER, 1968); "Pinzgauer Phyllit" (MOSTLER, 1968; BAUER et al., 1969); "Wildschönauer Schichten" (FLÜGEL, 1970).

**Lithology:** Monotonous sequence of light grey argillaceous and silty schists, and sandstones. The existence of extended Ordovician basaltic metavolcanics as suggested by MOSTLER (1968, 1984) is difficult to decide due to the lack of fossils and the severe Alpine tectonics (HEINISCH, 1986; SCHÖNLAUB & HEINISCH, 1993). Nevertheless pebbles of greenstones within the level of the "geröllführende Porphyroide" are a hint to Ordovician basic volcanics (MOSTLER, 1968).

**Fossils:** Acritarchs (REITZ & HÖLL, 1989, 1991).

**Origin, facies:** Basinal clastic environment.

**Chronostratigraphic age:** Ordovician (pre-Hirnantian).

**Biostratigraphy:** In parts of the unit Tremadocian to Dapingian acritarchs (REITZ & HÖLL, 1989, 1991) were recorded.

**Thickness:** Due to the heavy tectonics an estimation of the thickness is difficult. A thickness around 1,000 m seems realistic (MOSTLER, 1968).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Primary basement unknown.

**Overlying unit(s):** Blasseneck Porphyry.

**Lateral unit(s):** -

**Geographic distribution:** W-GWZ; Tyrol, Salzburg; Kitzbüheler Alpen, Dientener Berge, N Pongau.

**Remarks:** MOSTLER (1968) subdivided the Wildschönau Schists by the intercalation of the Blasseneck Porphyry into Lower and Upper Wildschönau Schists. In the ASC 2004 the Wildschönau Schists represent only the Lower Wildschönau Schists. Due to the lack of detailed mapping and biostratigraphy the Wildschönau Schists of the Tyrolian Wildschönau – Kitzbühel area cannot be linked easily with the siliciclastics around Saalbach – Zell am Zee (Salzburg) where HEINISCH (1986) differentiated several Silurian/Devonian formations (Löhnersbach, Schattberg and Klinglerkar Formations) in domains previously assigned to Wildschönau Schists. W of Zell am See they are part of the Glemmtal Unit (HEINISCH, 1986).

**Complementary references:** OHNESORGE (1905), MOSTLER (1970), TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), HEINISCH (1988), HEINISCH et al. (1987), SCHLAEGEL (1988), EBNER et al. (1989).

### **Blasseneck Porphyroid / Blasseneck Porphyry**

(description see E-GWZ)

### **Löhnersbach-Formation / Löhnersbach Formation**

FRITZ EBNER

**Validity:** Valid; formal description by HEINISCH et al. (1987).

**Type area:** ÖK50-UTM, map sheet 3221 Zell am See (ÖK50-BMN, map sheet 123 Zell am See).

**Type section:** Southern parts of the Löhnersbachtal, W of Zell am See, NE of Klingler Törl (N 47°19'45" / E 12°37'17"); ÖK50-UTM, map sheet 3221 Zell am See (ÖK50-BMN, map sheet 123 Zell am See) (HEINISCH et al., 1987).

**Reference section(s):** -

**Derivation of name:** After the Löhnersbach valley in the Kitzbüheler Alpen ca. 11 km WNW of Zell am See (ÖK50-UTM, map sheet 3221 Zell am See; ÖK50-BMN, map sheet 123 Zell am See).

**Synonyms:** Partim the "Höhere Wildschönauer Schiefer" (MOSTLER, 1968).

**Lithology:** Alternation of phyllites, metasiltstones and metasandstones. Within this sequence the average content of metasandstones is ~50 %. Wide areas are dominated by thin-bedded metasiltstones. Turbidite Bouma sequences are differently complete (HEINISCH, 1986).

**Fossils:** -

**Origin, facies:** Basinal distal turbidite facies (distal channel facies of deep sea fans; HEINISCH et al., 1987).

**Chronostratigraphic age:** Lower Silurian–Emsian (HEINISCH et al., 1987).

**Biostratigraphy:** -

**Thickness:** Max. 1,300 m (HEINISCH, 1988).

**Lithostratigraphically higher rank unit:** Wildschönau Group (sensu SCHÖNLAUB & HEINISCH, 1993).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Uppermost Ordovician–lower Silurian epiclastic porphyroid materials interpreted as equivalents or reworked parts of the Blasseneck Porphyry (HEINISCH & SCHÖNLAUB, 1993).

**Overlying unit(s):** Klinglerkar Formation (HEINISCH, 1988) and the Metabasite Group (HEINISCH, 1988; SCHLAEGEL-BLAUT, 1990; HEINISCH et al., 1995, 2003).

**Lateral unit(s):** In upper parts lower parts of the Klinglerkar Formation (SCHLAEGEL-BLAUT, 1990; HEINISCH, 1988).

**Geographic distribution:** W-GWZ; Tyrol, Salzburg, Kitzbüheler Alpen.

**Remarks:** This lithostratigraphic unit was proposed as a formation because MOSTLER's (1968) subdivision in Lower and Upper Wildschönau Shales is not applicable for the siliciclastic domains (Glemmtal Unit sensu HEINISCH, 1988) W of Zell am See (HEINISCH et al., 1987).

**Complementary references:** EBNER et al. (1989, 2008), SCHÖNLAUB & HEINISCH (1993).

### **Dienten-Schiefer / Dienten Schists**

FRITZ EBNER

**Validity:** Invalid; used for a long time in terms of a formation but not formalized.

**Type area:** Dientener Berge (ÖK50-UTM, map sheet 3221 Zell am See; ÖK50-BMN, map sheet 124 Saalfelden; ÖK50-UTM, map sheet 3222 St. Johann im Pongau; ÖK50-BMN, map sheet 125 Bischofshofen).

**Type section:** No type section is specified in the literature.

**Reference section(s):** -

Remarks: First descriptions (AIGNER, 1931; MOSTLER, 1966a) are related to the Lachtal-Grundalm SW Fieberbrunn (ÖK50-UTM, map sheet 3214 Kitzbühel; ÖK50-BMN, map sheet 122 Kitzbühel) and to the magnesite mine at Entachenalm (ÖK50-UTM, map sheet 3221 Zell am See; ÖK50-BMN, map sheet 124 Saalfelden) (FRIEDRICH & PELTZMANN, 1937).

**Derivation of name:** After the village of Dienten (N 47°23'04" / E 13°00'15"); ÖK50-UTM, map sheet 3221 Zell am See (ÖK50-BMN, map sheet 124 Saalfelden).

**Synonyms:** "Dientener Schiefer", partim: "Höhere Wildschönauer Schiefer" (MOSTLER, 1968; TOLLMANN, 1977).

**Lithology:** Black, aluminian and siliceous schists and lydite with some intercalations of bituminous limestone. Typical black Dienten Schists develop by the increase of black organic matter from light grey and much more sandy phyllite (Pinzgauer Phyllit = equivalent of the Wildschönau Schists; MOSTLER, 1968).

**Fossils:** Entachenalm and Lachtal-Grundalm: graptolites (HAIDEN, 1936; FRIEDRICH & PELTZMANN, 1937; JAEGER, 1978). Nagelschmidpalven/Dienten: bivalves, nautiloids (HAUER, 1847; STACHE, 1879; HERITSCH, 1929).

**Origin, facies:** Partly euxinic basin.

**Chronostratigraphic age:** Llandovery–middle Ludlow.

**Biostratigraphy:** Graptolite zones 27–29, 33 and 34/35 (JAEGER, 1978).

**Thickness:** Up to 200 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Conglomerates.

**Overlying unit(s):** Dolomite Lydite Group (MOSTLER, 1968; SCHÖNLAUB, 1979, 1980a).

**Lateral unit(s):** Kitzbühel area: Dolomites, Limestones with tuffs; W Zell am See: lower parts of the Löhnersbach Formation.

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen; Salzburg, Dientener Berge.

**Remarks:** -

**Complementary references:** BAUER et al. (1969), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Klinglerkar-Formation / Klinglerkar Formation

FRIITZ EBNER

**Validity:** Valid; formal description by HEINISCH et al. (1987). Note: spelling of the first description is Klingler Kar-Formation.

**Type area:** Glemmtal Unit of the Kitzbüheler Alpen W Zell am See (ÖK50-UTM, map sheet 3220 Mittersill; ÖK50-BMN, map sheet 123 Zell am See).

**Type section:** No type section is explicitly indicated, but HEINISCH et al. (1987: Fig. 2) refer to seven detailed sections mapped at the scale of 1:5,000 (HEINISCH et al., 1987) in the Klinglerkar (NE Klinglertörl, 2,059 m, N 47°19'45" / E 12°37'17"; ÖK50-UTM, map sheet 3220 Mittersill; ÖK50-BMN, map sheet 123 Zell am See). The sections 1–6 are situated along a stripe of 800 m and have a lateral distance of 100–200 m to each other. The seventh section is more distantly situated. The sections exhibit strong lateral lithological differentiations which can be correlated by marker horizons (metapillow lavas, lydite) and conodont biostratigraphy. The formation is subdivided into three subunits (members) assigned by HEINISCH et al. (1987) as “Lower, Middle and Upper Klingler-Kar-Formation” (in the following: “lower member”, “middle member”, “upper member”).

**Reference section(s):** -

**Derivation of name:** After the Klinglerkar in the Kitzbüheler Alpen W of Zell am See (ÖK50-UTM, map sheet 3220 Mittersill; ÖK50-BMN, map sheet 123 Zell am See).

**Synonyms:** Partim Wildschönauer Schichten in the older literature (e.g., MOSTLER, 1968).

**Lithology:** Limestones, lydites, black schists with sulphide mineralization, green and violet tuffitic schists, pyroclastic breccias and basaltic pillow lavas.

**Fossils:** Conodonts; nautiloids, radiolarians (“lower” and “middle member”).

**Origin, facies:** Deep basinal swell deposits outside the influence of siliciclastic turbiditic sedimentation with condensed cephalopod limestones, lydites and black schists (“lower member”) and fine input of clayey materials (“middle member”). The carbonate pelagic deep swell is covered by submarine basaltic flows and pyroclastics (“upper member”; HEINISCH et al., 1987).

**Chronostratigraphic age:** Uppermost Silurian (Pridoli)–Lower Devonian (Zlichovian regional stage = lower Emsian; HEINISCH et al., 1987). “Lower member”: uppermost Silurian (Pridoli); “middle member”: Lower Devonian (Lochkovian–lower Pragian); base of “upper member” within the lower Emsian.

**Biostratigraphy:** “Lower member”: *eosteinhornensis* Zone; “middle member”: conodont fauna with fragments of the *Icriodus woschmidti* – *postwoschmidti* – *Icriodus* sp. A

SCHÖNLAUB 1985 – *I. steinachensis* group. Base of the “upper member”: *Polygnatus gronbergi* – *Polygnatus serotinus* zones (HEINISCH et al., 1987).

**Thickness:** Up to 80 m (a: 10 to 13 m; b: 6 to 16 m; c: 5 to 35 m; HEINISCH et al., 1987).

**Lithostratigraphically higher rank unit:** Wildschönau Group (sensu SCHÖNLAUB & HEINISCH, 1993).

**Lithostratigraphic subdivision:** According to HEINISCH et al. (1987) three members can be distinguished: a) The “lower member” is characterized by limestone – lydite alternations, lydite and black schists with sulphide mineralization. The lydite is associated and interfingered with metamarl. b) The “middle member” exhibits rhythmic alternations of thin bedded calcareous marble and platy shale respectively metamarls. c) The “upper member” consists of epiclastic green and violet tuffitic and sometimes banded schists which are intercalated by white marble layers. They are followed by pyroclastic breccias and basaltic pillow lavas which interfinger laterally with metatuffite. All lithologies are of low metamorphic grade (CAI 5 to 8).

**Underlying unit(s):** Löhnersbach Formation.

**Overlying unit(s):** Schattberg Formation and parts of the Metabasite Group (HEINISCH et al., 1995) (not indicated in the ASC 2004).

**Lateral unit(s):** ?Upper Silurian–Lower Devonian siliciclastics of the “Wildschönau Group” (Löhnersbach Formation) and in uppermost parts Metabasite Group (SCHLAEGEL-BLAUT, 1990; HEINISCH et al., 1995, 2003).

**Geographic distribution:** W-GWZ; Tyrol, Salzburg, Kitzbüheler Alpen.

**Remarks:** This lithostratigraphic unit was proposed as a formation because MOSTLER’s (1968) subdivision in Lower and Upper Wildschönau Schists is not applicable for the siliciclastic domains W of Zell am See (HEINISCH et al., 1987).

**Complementary references:** HEINISCH (1986, 1988), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Metabasit-Gruppe / Metabasite Group

FRIITZ EBNER

**Validity:** Invalid; informal working term (HEINISCH et al., 1995, 2003).

**Type area:** Glemmtal Unit of the Kitzbüheler Alpen W Zell am See (ÖK50-UTM, map sheet 3214 Kitzbühel; ÖK50-BMN, map sheet 122 Kitzbühel; ÖK50-UTM, map sheet 3220 Mittersill, ÖK50-BMN, map sheet 123 Zell am See).

**Type section:** No type section was explicitly nominated.

**Reference section(s):** -

**Derivation of name:** According to the geochemistry of the metavolcanics.

**Synonyms:** Partim “Diabase”, “intrusive” Diabase (SCHÖNLAUB, 1979, 1980a), partim Basalt Sill Komplex von Maishofen (SCHLAEGEL-BLAUT, 1990).

**Lithology:** a) highly vesicular pillow and massive basalts, gabbroic sills, pyroclastics, tuffites. b) pillow and sheet-flows basalts, many gabbroic and some dioritic sills, thin shale intercalations (SCHLAEGEL-BLAUT, 1990; LOESCHKE & HEINISCH, 1993).

**Fossils:** -

**Origin, facies:** a) transitional and alkali oceanic island type intraplate basalts formed in a shallow marine environment (< 500 m below sea level). b) tholeiitic basalts extruded > 500 m below the sea level. The interpretation of the environment fits best with extensional processes in oceanic domains (marginal basin, oceanic plateau, sill-sediment complex connected with a continental rift zone; SCHLAEGEL-BLAUT, 1990; LOESCHKE & HEINISCH, 1993).

**Chronostratigraphic age:** a) Devonian (upper Emsian); for b) a younger age, possibly continuing until ?lower Carboniferous is assumed (HEINISCH, 1988; LOESCHKE & HEINISCH, 1993).

**Biostratigraphy:** -

**Thickness:** a) some hundreds of m (basalts 350 m, pyroclastics 400 m in maximum); b) 400 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kinglerkar Formation, Löhnersbach Formation (HEINISCH et al., 1995, 2003; SCHLAEGEL-BLAUT, 1990; LOESCHKE & HEINISCH, 1993).

**Overlying unit(s):** Schattberg Formation.

**Lateral unit(s):** In deeper parts Kinglerkar Formation; Schattberg Formation (LOESCHKE & HEINISCH, 1993).

**Geographic distribution:** W-GWZ; Salzburg, Kitzbüheler Alpen.

**Remarks:** Firstly the basic metavolcanics were regarded as Ordovician ocean floor basalts within the "Lower Wildschönau Schists" below the Blasseneck Porphyry (COLINS et al., 1980; MOSTLER, 1984).

**Complementary references:** SCHÖNLAUB (1980a), SCHÖNLAUB & HEINISCH (1993), EBNER et al. (2008).

### Schattberg-Formation / Schattberg Formation

FRITZ EBNER

**Validity:** Valid; formalized by HEINISCH et al. (1987).

**Type area:** Glemmtal Unit of the Kitzbüheler Alpen W Zell am See (ÖK50-UTM, map sheet 3220 Mittersill, ÖK50-BMN, map sheet 123 Zell am See).

**Type section:** No type section was explicitly nominated. The formation was described due to the situation in the Schattberg area (Mittlerer Schattberg: N 47°21'47" / E 12°37'38"; ÖK50-UTM, map sheet 3220 Mittersill, ÖK50-BMN, map sheet 123 Zell am See).

**Reference section(s):** -

**Derivation of name:** After Schattberg in the Kitzbüheler Alpen (ÖK50-UTM, map sheet 3220 Mittersill, ÖK50-BMN, map sheet 123 Zell am See).

**Synonyms:** Partim Wildschönauer Schichten in older literature (e.g., MOSTLER, 1968).

**Lithology:** Alternation of argillaceous schists, metasilstones and metasandstones. At one locality a layer of a metabreccia (with components up to 80 cm) occurs above the top of the Kinglerkar Formation (HEINISCH et al., 1987).

**Fossils:** -

**Origin, facies:** Basinal siliciclastic proximal turbidite facies in which the coarse grained intercalations are channel deposits of submarine fans (HEINISCH et al., 1988).

**Chronostratigraphic age:** Middle Devonian–?lower Carboniferous (HEINISCH et al., 1987; SCHÖNLAUB & HEINISCH, 1993).

**Biostratigraphy:** -

**Thickness:** > 450 m.

**Lithostratigraphically higher rank unit:** Wildschönau Group (sensu SCHÖNLAUB & HEINISCH, 1993).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Metabasite Group (HEINISCH et al., 1995, 2003; SCHLAEGEL-BLAUT, 1990).

**Overlying unit(s):** -

**Lateral unit(s):** In deeper parts Metabasite Group (LOESCHKE & HEINISCH, 1993).

**Geographic distribution:** W-GWZ; Salzburg, Kitzbüheler Alpen.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979, 1980a), HEINISCH (1986, 1988), EBNER et al. (1989, 2008).

### Carbonate facies (partim Wildseeloder unit in the Kitzbüheler Alpen)

#### Blasseneck Porphyroid / Blasseneck Porphyry (description see E-GWZ)

#### Konglomerate / Conglomerates

FRITZ EBNER

**Validity:** Invalid; not formalized informal working term.

**Type area:** ÖK50-UTM, map sheet 3214 Kitzbühel (ÖK50-BMN, map sheet 122 Kitzbühel).

**Type section:** Not yet indicated; best outcrops in the section of the Klausenbachgraben W of Kitzbühel (ÖK50-UTM, map sheet 3214 Kitzbühel; ÖK50-BMN, map sheet 122 Kitzbühel).

**Reference section(s):** -

**Derivation of name:** After the predominant lithology.

**Synonyms:** "Geröllführende Quarzporphyrtuff- und Grauwackenschiefer" (OHNESORGE, 1919).

**Lithology:** Schists with pebbles of porphyroid, feldspar- and quartzsandstones, lydites and basic volcanics. The sequence starts with fining upwards conglomerates which continue to a fine sandy horizon followed again by conglomerates. The "porphyroidic" matrix of deeper parts of the sequence changes to a clayey-sandy one in the upper parts. In the same direction the number of porphyroid pebbles decreases (MOSTLER, 1968).

**Fossils:** -

**Origin, facies:** Transgression conglomerate.

**Chronostratigraphic age:** Lowermost Silurian.

**Biostratigraphy:** -

**Thickness:** Up to 80 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Blasseneck Porphyry. A correlation with the lower Silurian global transgression suggests a strati-

graphic gap between the Conglomerates and the Blasseneck Porphyry (MOSTLER, 1968, 1970; SCHÖNLAUB, 1979).

**Overlying unit(s):** “Dolomites, Limestones with tuff” (MOSTLER, 1968, 1970).

**Lateral unit(s):** Arkose sandstone, fine grained conglomerate and graded sandstone (MOSTLER, 1968, 1970; AL-HASANI & MOSTLER, 1969) and shallow water limestones and dolomites (=“Dolomites, Limestones with tuffs” of the ASC 2004; MOSTLER, 1970; SCHÖNLAUB, 1979: Fig. 53, 1980a).

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen.

**Remarks:** The primary position of the “Conglomerates” below or above the Blasseneck Porphyry is not clear due to tectonic complication (MALZER, 1964; MOSTLER, 1968: p. 122).

**Complementary references:** OHNESORGE (1905, 1909), TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Dolomite, Kalke mit Tuffen / Dolomites, Limestones with tuffs

FRITZ EBNER

**Validity:** Invalid; not formalized informal working term.

**Type area:** In domains related to the Wildseeloder Unit (HEINISCH, 1988); ÖK50-UTM, map sheet 3213 Kufstein (ÖK50-BMN, map sheet 121 Neunkirchen), ÖK50-UTM, map sheet 3214 Kitzbühel (ÖK50-BMN, map sheet 122 Kitzbühel).

**Type section:** No type locality selected.

**Reference section(s):** Some sections at Lachtal-Grundlam, Lengfilzenbach, and Westendorf were described by MOSTLER (1968).

**Derivation of name:** After the main occurring lithologies.

**Synonyms:** “Kalke des tieferen Silurs”, “Kalke der amorphognathoides Zone” (MOSTLER, 1968); “Silur-Transgressionsbildungen” (SCHÖNLAUB, 1979).

**Lithology:** Strong regional variation of siliceous dolomites, red bedded siliceous limestones, nodular siliceous limestones, flaser limestone, black micritic limestone, stromatolitic and onkolithic dolomite, biogene-rich allodapic limestone; sometimes intercalations of sandy and volcanic (tuffitic) materials.

**Fossils:** Conodonts, ostracods, agglutinated foraminifers, bivalves, gastropods, crinoids.

**Origin, facies:** Marine shallow water and swell facies.

**Chronostratigraphic age:** Llandovery and lower Wenlock.

**Biostratigraphy:** *celloni* and *amorphognathoides* conodont zones (MOSTLER, 1968).

**Thickness:** Limestones of the swell facies: 5 m; shallow water carbonates up to 30 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Conglomerates.

**Overlying unit(s):** Dolomite-Lyditite Group.

**Lateral unit(s):** Transgression conglomerates (“Conglomerates”) or much more basinal fine-clastic rocks, sometimes influenced by gravitationally transported (calcareous and siliciclastic) materials (MOSTLER, 1970; SCHÖNLAUB, 1979: Fig. 53; not indicated in Text-Fig. 2).

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen (Wildseeloder Unit).

**Remarks:** Informal unit summarizing Llandovery–lower Wenlock ± siliceous limestones and dolomites which may also include sandy and volcanic materials (MOSTLER, 1968, 1970; SCHÖNLAUB, 1979: Tab. 3).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Dolomit-Kieselschiefer-Gruppe / Dolomite-Lyditite Group

FRITZ EBNER

**Validity:** Invalid; used in terms of a formation but not formalized.

**Type area:** ÖK50-UTM, map sheet 3214 Kitzbühel (ÖK50-BMN, map sheet 122 Kitzbühel); ÖK50-UTM, map sheet 3221 Zell am See (ÖK50-BMN, map sheet 124 Saalfelden).

**Type section:** No type section selected.

**Reference section(s):** -

**Derivation of name:** According to the prevailing lithology.

**Synonyms:** “Dolomit-Kieselschiefer-Komplex” (MOSTLER, 1966a), “Kalk-Kieselschiefer-Serie” (SCHÖNLAUB, 1979).

**Lithology:** Alternation of dark grey to black lydites with predominantly laminated biogene-rich dolomites (Kitzbühel area; MOSTLER, 1966a, 1968). The sequence of the Entachenalm (MOSTLER, 1966b) consists of an alternation of lydites/siliceous shales, black magnesite, dolomite and limestone.

**Fossils:** Conodonts, sponge-spicula, radiolarians, ostracods, bryozoans, agglutinated foraminifers, holothurians, crinoids (MOSTLER, 1966a, b, 1968).

**Origin, facies:** Partly euxinic basinal development.

**Chronostratigraphic age:** Middle Wenlock–lower Ludlow.

**Biostratigraphy:** *patula*, *sagitta*, *crassa* and *ploeckensis* conodont zones (MOSTLER, 1966a, b, 1968).

**Thickness:** 10–30 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Dienten Schists.

**Overlying unit(s):** “Dolomites”.

**Lateral unit(s):** Dienten Schists, Orthoceratid Limestone (at Spiessnägel, N 47°21'21" / E 12°18'27"; ÖK50-UTM, map sheet 3219 Neunkirchen; ÖK50-BMN, map sheet 121 Neunkirchen; AL-HASANI, 1969); parts of the Löhnersbach Formation.

Not shown in the ASC 2004 and Text-Fig. 2: Ludlow limestone of the Steigwand (N 47°19'26" / E 13°01'19"; ÖK50-UTM, map sheet 3222 St. Johann im Pongau, ÖK50-BMN, map sheet 124 Saalfelden; BAUER et al., 1969); alternation of calcareous schists and lydites from Langeck (N 47°21'21" / E 12°55'01"; ÖK50-UTM, map sheet 3221 Zell am See, ÖK50-BMN, map sheet 124 Saalfelden; BAUER et al., 1969).

**Geographic distribution:** W-GWZ; Tyrol, Salzburg; Kitzbüheler Alpen, Dientener Berge.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Orthocerenkalk / Orthoceratid Limestone

FRITZ EBNER

**Validity:** Invalid; not formalized. After the first description (AL-HASANI & MOSTLER, 1969) used as informal working term (SCHÖNLAUB, 1979, Tab. 3).

**Type area:** Spiessnägel in the Kitzbüheler Alpen/Tyrol; ÖK50-UTM, map sheet 3219 Neunkirchen (ÖK50-BMN, map sheet 121 Neunkirchen).

**Type section:** Spiessnägel S Kirchberg/Tyrol (N 47°21'21"/E 12°18'27"; ÖK50-UTM, map sheet 3219 Neunkirchen; ÖK50-BMN, map sheet 121 Neunkirchen; AL-HASANI & MOSTLER, 1969).

**Reference section(s):** -

**Derivation of name:** After lithologic characteristics and the occurrence of orthocon nautiloid cephalopods.

**Synonyms:** -

**Lithology:** Grey and rarely black limestones with strongly silicified nautiloids.

**Fossils:** Nautiloids, conodonts.

**Origin, facies:** Pelagic basinal facies.

**Chronostratigraphic age:** Lower–upper Ludlow.

**Biostratigraphy:** Conodonts of *ploeckensis*–?*eostein-hornensis* Zone.

**Thickness:** 17 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** “Dolomite, Limestone with tuffs”.

**Overlying unit(s):** In the Spiessnägel section “Dolomites” with inclusions of magnesite (AL-HASANI & MOSTLER, 1969).

**Lateral unit(s):** Dolomite-Lydite Group, upper parts of Di-enten Schists.

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen.

**Remarks:** -

**Complementary references:** MOSTLER (1968), TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Dolomit / Dolomites

FRITZ EBNER

**Validity:** Invalid; not formalized informal working term.

**Type area:** Kitzbüheler Alpen (ÖK50-UTM, map sheet 3219 Neunkirchen, ÖK50-BMN, map sheet 121 Neunkirchen; ÖK50-UTM, map sheet 3214 Kitzbühel, ÖK50-BMN, map sheet 122 Kitzbühel).

**Type section:** Within the Wildseeloder Unit (HEINISCH, 1988), but not indicated.

**Reference section(s):** -

**Derivation of name:** Named after the dominant lithology.

**Synonyms:** “Dolomite mit Magnesiteinschaltungen” (AL-HASANI & MOSTLER, 1969); “Schwarze Dolomite und Hellgraue Dolomite der Südfazies” (MAVRIDIS & MOSTLER, 1970); “Graue Dolomite der Kitzbüheler Horn-Serie” (EMMANUILIDIS & MOSTLER, 1970).

**Lithology:** Different types of black and grey, massive to bedded dolomites, subordinate with intercalations of limestone, calcareous dolomite, magnesite and siliceous shales (MAVRIDIS & MOSTLER, 1970).

**Fossils:** Conodonts, ostracods, radiolarians; from Lower Devonian limestone intercalations: crinoids, agglutinated foraminifers and brachiopods (AL-HASANI & MOSTLER, 1969; MAVRIDIS & MOSTLER, 1970; EMMANUILIDIS & MOSTLER, 1970).

**Origin, facies:** Pelagic basinal environment.

**Chronostratigraphic age:** Upper Ludlow–Lochkovian.

**Biostratigraphy:** Sporadic findings of conodonts indicate without a more exact determination late Silurian to Early Devonian (Lochkovian) ages (MOSTLER, 1968; AL-HASANI & MOSTLER, 1969; MAVRIDIS & MOSTLER, 1970; EMMANUILIDIS & MOSTLER, 1970).

**Thickness:** Mostly not indicated in the literature. Light grey Lochkovian dolomite of the “Südfazies” (MAVRIDIS & MOSTLER, 1970) may reach up to 140 m. In the hanging parts they include siliceous shales with a thickness of 3 m and intercalations of 22 m thick “Netzkalke” (MAVRIDIS & MOSTLER, 1970).

**Lithostratigraphically higher rank unit:** “Südfazies” (MAVRIDIS & MOSTLER, 1970), “Kitzbüheler Horn-Serie” (EMMANUILIDIS & MOSTLER, 1970) – both informal.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Dolomite-Lydite Group.

**Overlying unit(s):** Spielberg and Schwaz Dolomite as well as “Dolomites, Flaser Limestones”.

**Lateral unit(s):** -

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen.

**Remarks:** In the Kitzbüheler Alpen, especially within the Wildseeloder Unit (HEINISCH, 1988) the sequence above the Orthoceratid Limestone and the Dolomite-Lydite Group is made up of a carbonate facies (= partly “Südfazies” of MAVRIDIS & MOSTLER, 1970) dominated by thick dolomites. The Spielberg Dolomite and Schwaz Dolomite form two distinct Lower Devonian “formations” within this facies. Other dolomite niveaus were named in the ASC 2004 by working terms as “Dolomites” (uppermost Silurian–Lower Devonian) and “Dolomites, Flaser Limestones” (Lower Devonian; Frasnian–Famennian), respectively.

**Complementary references:** AL-HASANI & MOSTLER (1969), TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), HEINISCH & SCHÖNLAUB (1993).

### Schwaz-Dolomite / Schwaz Dolomite

FRITZ EBNER

**Validity:** Invalid; since the first denomination (PICHLER, 1860) and detailed description (PIRKL, 1961) used in terms of a formation but without formalization.

**Type area:** ÖK50-UTM, map sheet 2224 Schwaz (ÖK50-BMN, map sheets 119 Schwaz and 120 Wörgl).

**Type section:** Not yet indicated.

**Reference section(s):** -

**Derivation of name:** After the town of Schwaz in Tyrol (ÖK50-UTM, map sheet 2224 Schwaz, ÖK50-BMN, map sheet 119 Schwaz) and the predominant lithology.

**Synonyms:** Schwazer Dolomit (PICHLER, 1860; PIRKL, 1961); Spielberg-Dolomit (TOLLMANN, 1977: p. 494).

**Lithology:** Grey, coarse sparry dolomite subdivided into two types: a) laminated dolomite without fossils and biotrititic material in the lower parts; b) dolomitic and biotrititic limestones and dolomite in the upper parts (PIRKL, 1961; MOSTLER, 1968).

**Fossils:** Nautilids, crinoids, corals, bivalves, conodonts.

**Origin, facies:** Shallow water shelf environment.

**Chronostratigraphic age:** Lower Devonian (Lochkovian–Pragian).

**Biostratigraphy:** Conodonts (PIRKL, 1961; MOSTLER, 1964, 1968) point to Lochkovian–Pragian ages.

**Thickness:** 600 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** “Dolomites”.

**Overlying unit(s):** -

**Lateral unit(s):** Spielberg Dolomite, “Dolomites, Flaser Limestones”.

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen.

**Remarks:** see unit “Dolomites”.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989).

### Spielberg-Dolomit / Spielberg Dolomite

FRITZ EBNER

**Validity:** Invalid; since the first description by MAVRIDIS & MOSTLER (1970) used in terms of a formation but without formalization.

**Type area:** Kitzbüheler Alpen (ÖK50-UTM, map sheet 3214 Kitzbühel, ÖK50-BMN, map sheet 123 Zell am See).

**Type section:** At Spielberghorn but not further indicated in the literature.

**Reference section(s):** -

**Derivation of name:** After the Mt. Spielberghorn (N 47°25'57" / E 21°37'56"; ÖK50-UTM, map sheet 3214 Kitzbühel, ÖK50-BMN, map sheet 123 Zell am See) in the Kitzbüheler Alpen.

**Synonyms:** Partly “Schwaz-Dolomit” (TOLLMANN, 1977: p. 494); “Wilde Hag-Pfeiferkogel-Serie” (EMMANULIDIS & MOSTLER, 1970).

**Lithology:** Light dolomite, rarely with reddish-grey and partly black dolomite (MAVRIDIS & MOSTLER, 1970; EMMANULIDIS & MOSTLER, 1970).

**Fossils:** Detritus of crinoids, corals, bryozoans, gastropods, stromatoporids and ostracods (MAVRIDIS & MOSTLER, 1970; EMMANULIDIS & MOSTLER, 1970).

**Origin, facies:** Shallow water shelf environment (reworked biostromes) (MAVRIDIS & MOSTLER, 1970).

**Chronostratigraphic age:** Lower Devonian–?Eifelian.

**Biostratigraphy:** Corals indicate a Devonian age.

**Thickness:** Some hundreds of meters?

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** “Dolomites”.

**Overlying unit(s):** “Dolomites, Flaser Limestones”.

**Lateral unit(s):** Schwaz Dolomite, “Dolomites, Flaser Limestones”.

**Geographic distribution:** W-GWZ; Tyrol, Salzburg, Kitzbüheler Alpen.

**Remarks:** The younger age (?Emsian–?Eifelian) of the Spielberg Dolomite is the reason for separating it from the Schwaz Dolomite (MAVRIDIS & MOSTLER, 1970). For further remarks see unit “Dolomites”.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Dolomite, Flaserkalke / Dolomites, Flaser Limestones

FRITZ EBNER

**Validity:** Invalid; not formalized informal working term (SCHÖNLAUB & HEINISCH, 1993).

**Type area:** Kitzbüheler Alpen (ÖK50-UTM, map sheet 3214 Kitzbühel, ÖK50-BMN, map sheet 122 Kitzbühel).

**Type section:** Within the Wildseeloder Unit at the Spielberg and Kitzbüheler Horn, not further indicated.

**Reference section(s):** -

**Derivation of name:** According to the main lithologies.

**Synonyms:** Rote Flaserdolomite, dunkle Dolomite mit hohem Tongehalt, dunkelgraue, grobspätige Dolomite, Tonschiefer, Kalktonschiefer, Tonflaserkalke und Kiesel-schiefer der “Südfazies” (MAVRIDIS & MOSTLER, 1970); “rot-gefärbte Dolomite/Flaserdolomite der Kitzbüheler Horn Serie” (EMMANULIDIS & MOSTLER, 1970).

**Lithology:** Dolomite (red-reddish flaser- and nodular dolomite, dark grey coarse sparry dolomite, dark clayey dolomite), flaser limestones with Fe-Mn crusts, shales, siliceous shales (EMMANULIDIS & MOSTLER, 1970; MAVRIDIS & MOSTLER, 1970).

**Fossils:** Conodonts, nautiloids, crinoids (EMMANULIDIS & MOSTLER, 1970; MAVRIDIS & MOSTLER, 1970).

**Origin, facies:** Basinal, pelagic environment.

**Chronostratigraphic age:** Devonian (?upper Lochkovian–lower Famennian) (EMMANULIDIS & MOSTLER, 1970; MAVRIDIS & MOSTLER, 1970).

**Biostratigraphy:** Exact dating is only possible in the early Late Devonian by species of the conodont genus *Palmatolepis*.

**Thickness:** About 30 m.

**Lithostratigraphically higher rank unit:** “Südfazies” (MAVRIDIS & MOSTLER, 1990), “Kitzbüheler Horn-Serie” (EMMANULIDIS & MOSTLER, 1970) – both units are informal.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** “Dolomites”.

**Overlying unit(s):** -

**Lateral unit(s):** Kitzbüheler Alpen: Schwaz and Spielberg Dolomite, Dientener Berge (Entachen Alm; ÖK50-UTM, map sheet 3221 Zell am See, ÖK50-BMN, map sheet 124 Saalfelden): red dolomite interfingering with reddish limestone or metasomatic magnesite (MOSTLER, 1968).

**Geographic distribution:** W-GWZ; Tyrol, Kitzbüheler Alpen.

**Remarks:** See remarks at unit “Dolomites”.

### E-Grauwackenzone / Eastern Greywacke Zone (E-GWZ)

The E-GWZ is dominated by Variscan fold and thrust tectonics as well as Alpine imbrication and thrust tectonics. The Alpine structure was arranged during the Eo-Alpine (Early to Mid-Cretaceous) thrusting and the formation of top to the NW directed ductile fabrics under low grade metamorphic conditions, which did not exceed significantly 350–400°C (NEUBAUER et al., 1994; RANTITSCH et al., 2004). All units of the E-GWZ were covered primarily by Permo-Mesozoic sediments. For the primary arrangement of the individual tectonic units before Alpine thrusting the following position is suggested from ESE to WNW (NEUBAUER et al., 1994): Noric Nappe – Kaintaleck Nappe – Silbersberg Nappe – Veitsch Nappe – “Middle Austroalpine” Unit (= Silvretta-Seckau Nappe; SCHMID et al., 2004).

The key area for stratigraphic investigations in the Noric Nappe is around Eisenerz (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz) where detailed stratigraphic studies were carried out mainly on the basis of conodonts by FLAJS and SCHÖNLAUB in the 1970s and 1980s. During this period summarizing lithological terms used earlier, as e.g., “Feinschichtige Grauwackenschiefer” and “Erzführender Kalk” were replaced by lithostratigraphic units documented in the ASC 2004 (PILLER et al., 2004). However, most of these units are only described as working terms in an informal way and named according to their characteristic lithologies. In the very eastern parts of the Noric Nappe modern stratigraphic studies are entirely missing.

Modern stratigraphic research of the Veitsch Nappe was concentrated at the Hohentauern-Sunk area (RATSCHBACHER, 1984, 1987). The sequences of the Kaintaleck and the Silbersberg Nappes are not represented in the ASC 2004. The first includes a pre-middle Paleozoic metamorphic basement and the second is composed of Lower Paleozoic quartzphyllite and Verrucano-type (Permo-Triassic) metaclastics (NEUBAUER et al., 1994). Additionally, the Silbersberg Nappe is intruded at one site (Gloggnitz) by a 110(?)–140 Ma old magmatic rock (Riebeckit gneiss; NEUBAUER et al., 1994).

#### Noric Nappe

The stratigraphic sequence of the Noric Nappe is similar to that of the W-GWZ. Especially the Blasseneck Porphyry forms an excellent stratigraphic marker, which can be followed along the GWZ for 320 km from Gloggnitz (Lower Austria) in the E as far as to Schwaz in Tyrol in the W.

#### Kalwang Konglomerate / Kalwang Conglomerate

FRITZ EBNER

**Validity:** Invalid; lithologically well described unit (DAURER & SCHÖNLAUB, 1978) of uncertain age and position.

**Type area:** Eisenerzer Alpen (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 131 Kalwang).

**Type section:** Lange Teichen valley (N 47°28'16" / E 14°48'35") NE Kalwang (ÖK50-UTM, map sheet 4215

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

Eisenerz, ÖK50-BMN, map sheet 131 Kalwang) (DAURER & SCHÖNLAUB, 1979; LOESCHKE et al., 1990).

**Reference section(s):** -

**Derivation of name:** After the village of Kalwang (N 47°25'39" / E 14°45'26"), ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 131 Kalwang) and the lithology.

**Synonyms:** “Kalwang Gneiskonglomerat” (DAURER & SCHÖNLAUB, 1978).

**Lithology:** Greenschists (metatuffs; chlorite-actinolite-epidote schists) including a package of banded greenschists (metatuffs) with pebbles of gneisses (=Kalwang Conglomerate with pebbles of quartz-rich metagranitoids, albite-granite gneisses and quartz). The greenschists are overlain by white micamarble (DAURER & SCHÖNLAUB, 1978; LOESCHKE et al., 1990).

**Fossils:** -

**Origin, facies:** Debris flow within greenschists in the Lange Teichen valley (LOESCHKE et al., 1990) or a transgressive conglomerate above the Kaintaleck metamorphic complex (NEUBAUER et al., 1994).

**Chronostratigraphic age:** Ordovician or post-Devonian. The latter is depending on the correctness of the correlation of the Kalwang Conglomerate with the conglomerate at Frauenberg (NEUBAUER, 1985; NEUBAUER et al., 1994).

**Biostratigraphy:** -

**Thickness:** Lange Teichen valley: greenschists 50 m, conglomerates 15 m, marble 15 m; Frauenberg: conglomerate 15 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Units of the Veitsch Nappe in tectonic contact (SCHÖNLAUB, 1979).

**Overlying unit(s):** Gerichtsgraben Formation.

**Lateral unit(s):** Conglomerate at Frauenberg (NEUBAUER, 1985) – not indicated in the ASC 2004.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen, ESE of Kapfenberg.

**Remarks:** The position of the Kalwang Conglomerate is strongly under discussion. Previously, as also shown in the ASC 2004, the Kalwang Conglomerate was regarded as the pre-Late Ordovician structural base of the Noric Nappe of the E-GWZ (DAURER & SCHÖNLAUB, 1978; SCHÖNLAUB, 1979, 1982a, b; LOESCHKE et al., 1990). Later, supported by thrust planes mapped above the Kalwang Conglomerate in the Lange Teichen valley, LOESCHKE et al. (1990) interpreted the Kalwang Conglomerate as a tectonic unit below the Noric Nappe. Finally, the Kalwang Conglomerate is regarded as an equivalent of gneiss conglomerates superposing the Frauenberg metamorphic complex ESE Kapfenberg (area of Frauenberg, N 47°25'29" / E 15°20'33"; ÖK50-UTM, map sheet 4217 Kindberg, ÖK50-BMN, map sheet 134 Passail) (NEUBAUER, 1985). There age data for metamorphism and magmatism range from 520 to 360 Ma



(DALLMEYER et al., 1992; HANDLER et al., 1999) and the unconformable sedimentary contact between the metamorphics and the conglomerates suggests a post-Middle Devonian age and a position of this conglomerate within the Kaintaleck Nappe of the E-GWZ (NEUBAUER et al., 1994).

**Complementary references:** SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Gerichtsgraben-Formation / Gerichtsgraben Formation

FRITZ EBNER

**Validity:** Invalid; first detailed description in the rank of a group by FLAJS & SCHÖNLAUB (1976). In the ASC 2004 this unit was regarded as a formation, it is, however, not formalized.

**Type area:** Präbichl area SE Eisenerz (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** NE flank of Gerichtsgraben SE of Eisenerz (N 47°32'11" / E 14°55'39"; ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz) along the road from Präbichl Pass to Gsollgraben.

**Reference section(s):** -

**Derivation of name:** After the Gerichtsgraben SE of Eisenerz (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz).

**Synonyms:** Partim "Feinschichtige quarzitische Grauwackenschiefer" (HAMMER, 1925); "Silurdevon" (HIESSLEITNER, 1929), "Gerichtsgraben Gruppe" (FLAJS & SCHÖNLAUB, 1976); partim "Untere Schiefer" (FLAJS & SCHÖNLAUB, 1976); "Schichten unter dem Porphyroid" (DAURER & SCHÖNLAUB, 1978; SCHÖNLAUB, 1982a).

**Lithology:** Uniform grey sericite schists, microfolded phyllitic schists, platy sandstones and schists with detrital mica; subordinate greywacke and graphite schists. Relicts of graded bedding and cross bedding are rare. Intercalations of grey-yellowish and sometimes banded limestones occur especially in three levels along the road from Präbichl to Eisenerz at the NE flank of the Gerichtsgraben. Laterally, they interfinger with metamarls and predominantly dark schists. Other intercalations are banded lydites (FLAJS & SCHÖNLAUB, 1976; SCHÖNLAUB, 1982a).

**Fossils:** Conodonts (FLAJS & SCHÖNLAUB, 1976).

**Origin, facies:** Fine-clastic, sometimes calcareous and euxinic basinal environment.

**Chronostratigraphic age:** Upper Ordovician (Katian) (FLAJS & SCHÖNLAUB, 1976).

**Biostratigraphy:** Conodonts from the limestone intercalations belong to the *Amorphognatoides ordovicicus* Zone (upper Katian–Hirnantian).

**Thickness:** Strong regional variation from 300 m (Polster area; ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz) to > 1,000 m in the Lange Teichen valley (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 131 Kalwang).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Deeper tectonic units of the E-GWZ (Kaintaleck Nappe, Silbersberg Nappe, Veitsch Nappe) (SCHÖNLAUB, 1979; NEUBAUER et al., 1994).

**Overlying unit(s):** Blasseneck Porphyry.

**Lateral unit(s):** Due to the superposition by the Blasseneck Porphyry the sequences around the Präbichl Pass and along the Lange Teichen valley should be at least partly stratigraphic equivalents.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** In the Präbichl area the strata below the Blasseneck Porphyry were summarized as the Gerichtsgraben Group by FLAJS & SCHÖNLAUB (1976). For a possible position of the Kalwang Conglomerate at the structural base of the Gerichtsgraben Formation see the description of the Kalwang Conglomerate.

**Complementary references:** SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Quarzite / Quartzites

FRITZ EBNER

**Remarks:** Metaclastics of the Gerichtsgraben Fm. always include intercalations of metasandstones and quartzites. A prominent occurrence of quartzite as shown in the ASC 2004 is overestimated and therefore not mentioned in Text-Fig. 2.

### Kaintalgraben-Formation / Kaintalgraben Formation

FRITZ EBNER

**Validity:** Invalid; first description as "Kaintal-Porphyroid" by HERMANN (1992) which was later named Kaintalgraben Formation (NEUBAUER et al., 1994).

**Type area:** ÖK50-UTM, map sheet 4216 Bruck an der Mur (ÖK50-BMN, map sheets 132 Trofaiach and 133 Leoben).

**Type section:** Along Kaintalbach valley, ~4,6 km NNE Trofaiach (N 47°26'39" / E 15°04'17"), ÖK50-UTM, map sheet 4216 Bruck an der Mur (ÖK50-BMN, map sheet 132 Trofaiach). In the early literature (HAUSER, 1938) micaschists were described from this location.

**Reference section(s):** -

**Derivation of name:** After the valley Kaintalgraben (ÖK50-UTM, map sheet 4216 Bruck an der Mur, ÖK50-BMN, map sheet 132 Trofaiach).

**Synonyms:** "Kaintal-Porphyroid" (HERMANN, 1992); "Kaintalgraben Porphyroid" (NEUBAUER et al., 1994).

**Lithology:** Light, strongly deformed and mm-laminated porphyroids with porphyroblastic texture (with potassium feldspar, plagioclase and quartz).

**Fossils:** -

**Origin, facies:** Ignimbrite, caused by a pyroclastic density current.

**Chronostratigraphic age:** ?Upper Ordovician.

**Biostratigraphy:** -

**Thickness:** Up to 80 m.

**Lithostratigraphically higher rank unit:** "Norische Gruppe" (invalid) (HERMANN, 1992).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Phyllites of the Gerichtsgraben Formation.

**Overlying unit(s):** Quartzitic phyllites of the Gerichtsgraben Formation.

**Lateral unit(s):** Gerichtsgraben Formation; ? correlation with acid tuffs above the Kalwang Conglomerate N Kalwang/Lange Teichen valley (LOESCHKE et al., 1990; NEUBAUER et al., 1994: p. 69).

**Geographic distribution:** E-GWZ; Styria, Kaintaleck area.

**Remarks:** -

**Complementary references:** -

### Blasseneck Porphyroid / Blasseneck Porphyry

FRITZ EBNER

**Validity:** Invalid; lithostratigraphic unit used since PANTZ & ATZL (1814) in terms of a formation but not formalized; well characterized by HEINISCH (1981).

**Type area:** Eisenerzer Alpen, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz) and ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 131 Kalwang).

**Type section:** Not yet indicated.

**Reference section(s):** -

**Derivation of name:** After Mt. Blaseneck (N 47°29'54" / E 14°37'09"), ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 131 Kalwang) in the Eisenerzer Alpen/Styria. The correct writing of the type locality in the ÖK50-BMN, map sheet 131 Kalwang is Blaseneck!

**Synonyms:** "Blasseneckgneis" (FOULLON, 1886); "Körnige Grauwacke, obere körnig-schiefrige Grauwacke" (SCHOUPEPÉ, 1854; VACEK, 1900).

**Lithology:** Some types of ignimbrites, unwelded tuffs and volcanoclastics, often intensively intercalated with fine siliciclastic rocks. Geochemically alkali-rhyolitic and rhyolitic types are dominating over rhyodacite, dacite and trachyandesite (HEINISCH, 1981).

**Fossils:** -

**Origin, facies:** Thick sequences are interpreted as sub-aerially extruded ignimbrites in topographic highs whereas the volcanic debris has been washed by sediment flows into shallow marine basins (MOSTLER, 1970; HEINISCH, 1981; HEINISCH & SCHÖNLAUB, 1993). They resulted from an extended late Ordovician magmatic event which is evident overall the Eastern and Southern Alps. However, modern plate tectonic concepts are not sufficient to explain the geodynamic relevance of this "Porphyroid"-event (HEINISCH, 1981; LOESCHKE & HEINISCH, 1993).

**Chronostratigraphic age:** Upper Ordovician (Katian–Hirnantian).

**Biostratigraphy:** In the E-GWZ dating was possible due to the position of the Blasseneck Porphyry between formations with conodonts of the *Amorphognathus ordovicicus* Zone (FLAJS & SCHÖNLAUB, 1976). The porphyroids of the W-GWZ were correlated with the Blasseneck Porphyry of the E-GWZ due to lithological criteria and their position below Llandoveryan limestones dated by conodonts (MOSTLER, 1964, 1968, 1970).

**Thickness:** The thickness of the total volcanogenic sequence including all clastic and volcanoclastic materials displays strong regional differences even along short distances (HEINISCH, 1981: Figs. 2, 3).

W-GWZ: up to 600 m; E-GWZ: Eisenerzer Alpen: up to 1,500 m (Polster area: 400 m, Rötziggraben: > 1,000 m, Blaseneck: 1,500 m).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** E-GWZ: Gerichtsgraben Formation (FLAJS & SCHÖNLAUB, 1976; SCHÖNLAUB, 1982a, b).

W-GWZ: Wildschönau Schists (MOSTLER, 1970; SCHÖNLAUB, 1979, 1980a). In the Wildseeloder Unit W Zell am See the underlying schists are sheared off (HEINISCH, 1988).

**Overlying unit(s):** The Blasseneck Porphyry is overlain above erosional unconformities in the E-GWZ by the Polster Quartzite (FLAJS & SCHÖNLAUB, 1976) and in the W-GWZ by "Conglomerates" and Llandoveryan "Dolomites, Limestones with tuffs" (MOSTLER, 1964, 1968, 1970).

**Lateral unit(s):** W-GWZ: parts of the Wildschönau Schists. E-GWZ: Volcanoclastics and coarse quartzites (= reworked Blasseneck Porphyry; SCHÖNLAUB, 1982a).

**Geographic distribution:** W-GWZ: Tyrol – Salzburg: Kitzbüheler Alpen, Dientener Berge, N Pongau.

E-GWZ: from the Eisenerzer Alpen in Styria to Gloggnitz in Lower Austria (HEINISCH, 1981).

**Remarks:** In the GWZ a great variety of low grade metamorphic acid volcanic rocks of calc-alkaline geochemical character is summarized within the Blasseneck Porphyry. The volcanic origin of these rocks was already recognized by PANTZ & ATZL (1814), some later authors, however, postulated a paragne formation until the volcanogenic origin was renewed (OHNESORGE, 1905; REDLICH, 1907, 1908).

**Complementary references:** ANGEL (1919), OHNESORGE (1909), CORNELIUS (1952a), FLAJS (1964), MALZER (1964), EBERHARD & MOSTLER (1966), BAUER et al. (1969), MAVRIDIS & MOSTLER (1970), LOESCHKE (1977), TOLLMANN (1977), EBNER et al. (1989), SCHLAEGEL-BLAUT (1990), SCHÖNLAUB & HEINISCH (1993).

### Lydite, Arkosen, Schiefer / Lydites, Arkoses, Schists

FRITZ EBNER

**Validity:** Invalid; informal working term.

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz, ÖK50-BMN, map sheets 131 Kalwang and 132 Trofaiach).

**Type section:** Not indicated.

**Reference section(s):** -

**Derivation of name:** According to lithologies.

**Synonyms:** Partim "(feinschichtige) Grauwackenschiefer" (HAMMER, 1924); "Schiefer über dem Porphyroid i.A." (SCHÖNLAUB & DAURER, 1978), Grauwackenschiefer (SCHÖNLAUB, 1982a).

**Lithology:** Grey-striped schists, sericitic schists, sandy schists, black schists, alun schists, marly schists, lydites, arkoses and sandstones associated with basic metavolcanics and scattered dark limestones.

**Fossils:** Some conodonts in limestones of the hanging parts.

**Origin, facies:** Basinal environment, partly euxinic and with volcanic influence.

**Chronostratigraphic age:** ?Upper Ordovician–Silurian (Llandovery/lower Wenlock).

**Biostratigraphy:** *amorphognathoides* conodont zone (SCHÖNLAUB, 1977b).

**Thickness:** > 1,000 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Blasseneck Porphyry, Gerichtsgraben Formation.

**Overlying unit(s):** Crinoidal Limestones (SCHÖNLAUB, 1982a).

**Lateral unit(s):** Polster Quartzite, Cystoid Limestone.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** Working term of SCHÖNLAUB (1982a) for ?Upper Ordovician–Silurian metaclastics and lydites above the Blasseneck Porphyry. Thick basic volcanics included within this unit are separated as “Volcanics” in the ASC 2004.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), FLAJS & SCHÖNLAUB (1973), SCHÖNLAUB & HEINISCH (1993).

### Polster Quarzite / Polster Quartzite

FRITZ EBNER

**Validity:** Invalid; detailed descriptions (FLAJS & SCHÖNLAUB, 1976; STATTEGGER, 1980) are used in terms of a formation but not formalized.

**Type area:** Präbichl area, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Polsterkar (N 47°32'05" / E 15°00'55"), ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** According to the lithology and the mountain Polster (1,910 m; N 47°31'11" / E 14°58'28") in the Eisenerzer Alpen; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Synonyms:** “Rogenstein-Quarzit” (HIESSLEITNER, 1929).

**Lithology:** Grey to grey-brownish massive and indistinctly bedded, coarsening upwards quartzites (diameter of quartz components: 2 mm to 0.5 mm) (FLAJS & SCHÖNLAUB, 1976; STATTEGGER, 1980).

**Fossils:** Imprints of brachiopods, bryozoans (REDLICH, 1923; HERITSCH, 1927a; SCHOUPE, 1950).

**Origin, facies:** Sandy coastal transgressional sequence with detrital material deriving from a low grade metamorphic hinterland and the reworked underlying Blasseneck Porphyry (STATTEGGER, 1980).

**Chronostratigraphic age:** Upper Ordovician (Katian–Hirnantian).

**Biostratigraphy:** *amorphognathoides ordovicicus* Zone is assumed due to conodonts in the footwall and hanging wall (see Gerichtsgraben Formation and Cystoid Limestone, respectively; FLAJS & SCHÖNLAUB, 1976; SCHÖNLAUB, 1982a).

**Thickness:** 60–80 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Blasseneck Porphyry (erosional unconformity?).

**Overlying unit(s):** Cystoid Limestone.

**Lateral unit(s):** Petersbaumgraben Formation (PGF in Text-Fig. 2).

**Geographic distribution:** E-GWZ; Styria, NE Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Petersbaumgraben-Formation / Petersbaumgraben Formation [= acronym PGF in Text-Fig. 2]

FRITZ EBNER

**Validity:** Invalid; first, but not formalized description in the rank of a formation as “Petersbauernbach-Formation” by HERMANN (1992) which was later re-named to Petersbaumgraben Formation (NEUBAUER et al., 1994; PILLER et al., 2004).

**Type area:** Petersbauernbachgraben, ÖK50-UTM, map sheet 4216 Bruck an der Mur (ÖK50-BMN, map sheet 132 Trofaiach).

**Type section:** NE striking ridge W of Petersbauernbach (N 47°27'41" / E 15°03'16"), ÖK50-UTM, map sheet 4216 Bruck an der Mur (ÖK50-BMN, map sheet 132 Trofaiach); not described in detail by HERMANN (1992).

**Reference section(s):** -

**Derivation of name:** After the Petersbauernbach valley, ÖK50-UTM, map sheet 4216 Bruck an der Mur (ÖK50-BMN, map sheet 132 Trofaiach) which name was later wrongly changed to Petersbaumgraben (NEUBAUER et al., 1994) and also adopted in the ASC 2004.

**Synonyms:** “Petersbauernbach Formation” (HERMANN, 1992).

**Lithology:** The sequence starts with alternating black siliceous schists, phyllites and some ignimbritic layers followed by horizons of conglomerates/breccias, light sandstones and phyllitic quartzites. The top is made up by dark phyllites with thin intercalations of coarse sands and fine conglomerates (HERMANN, 1992).

**Fossils:** -

**Origin, facies:** -

**Chronostratigraphic age:** ?Uppermost Ordovician.

**Biostratigraphy:** -

**Thickness:** 60 m.

**Lithostratigraphically higher rank unit:** “Norische Gruppe” (HERMANN, 1992).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Blasseneck Porphyry.

**Overlying unit(s):** Rad Schists (HERMANN, 1992).

**Lateral unit(s):** Polster Quartzite.

**Geographic distribution:** E-GWZ; Styria, NE Trofaiach.

**Remarks:** According to the ÖK50-BMN, map sheet 132 Trofaiach the today's name of the type locality is Petersbauernbach.

**Complementary references:** -

## Cystoideen Kalke / Cystoid Limestone

FRITZ EBNER

**Validity:** Invalid; not formalized working term. First detailed description by FLAJS & SCHÖNLAUB (1976).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Ca. 30 m (altitude 1,575 m) above the bend (N 47°31'44" / E 14°58'03") of the Knappensteig (trail from Präbichl Pass to Leobner Hütte) at the ridge separating the Polsterkar and the Polster S-slope (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** Due to the occurrence of debris and some theca of cystoidea (FLAJS & SCHÖNLAUB, 1976).

**Synonyms:** -

**Lithology:** Light grey to pinkish spotted, indistinctly bedded, pure sparry limestones with weak flaser texture followed by 5 m calcareous sandstones (FLAJS & SCHÖNLAUB, 1976).

**Fossils:** Recrystallized cystoids (debris and theca), rich conodont fauna (FLAJS & SCHÖNLAUB, 1976).

**Origin, facies:** Marine shallow water environment.

**Chronostratigraphic age:** Upper Ordovician (upper Katian–Hirnantian) (FLAJS & SCHÖNLAUB, 1976).

**Biostratigraphy:** *amorphognathus ordovicicus* conodont zone (FLAJS & SCHÖNLAUB, 1976).

**Thickness:** 13 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Polster Quartzite.

**Overlying unit(s):** "Red Sparitic Limestone" (FLAJS & SCHÖNLAUB, 1976: Fig. 3); ? transgressional contact.

**Lateral unit(s):** "Übergangsporphyroid" at Erzberg (KERN, 1927; SCHÖNLAUB, 1982a; not indicated in Text-Fig. 2): alternation of 6–8 m thick dm-bedded light limestones with greenish grey sandy layers followed by ankeritic material.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

## Vulkanite / Volcanics

FRITZ EBNER

**Validity:** Invalid; not formalized working term.

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheets 131 Kalwang and 132 Trofaiach).

**Type section:** Not defined. Detailed descriptions derive from the mountain Kragelschinken (1,845 m, N 47°29'21" / E 14°49'26") and along the section in the upper Lange Teichen valley (starting NNE of the foot of Mt. Wildfeld, N 47°28'18" / E 14°48'29") (HIESSLEITNER, 1931; SCHÖNLAUB, 1977a, b, 1982a, b).

**Reference section(s):** -

**Derivation of name:** According to lithology.

**Synonyms:** "Kragelschinken Folge" (EBNER et al., 1989); "Basische Vulkanite" in the geological map 1:25,000 (SCHÖNLAUB, 1982a).

**Lithology:** Alternation of mottled schists ("Fleckenschiefer" = green schists with dark spots of chlorite), diabase schists, sandy-quartzite schists and subordinate layers of massive plagioclase-hornblende rocks (HIESSLEITNER, 1931; DAURER in SCHÖNLAUB, 1982a). Parts of the sequence are characterized as volcanoclastics (lapilli and ash tuffs), basaltic lavas with well preserved pillow structures and concordant swarms of gabbroidic sills (SCHLAEGEL-BLAUT, 1990).

**Fossils:** Conodonts, crinoids from intercalations of Crinoidal Limestone (SCHÖNLAUB, 1977a, b).

**Origin, facies:** Two sections (Finzenkogel, Schleichberg) NW Trofaiach (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 132 Trofaiach) were characterized by SCHLAEGEL-BLAUT (1990) in terms of volcanic islands (sensu FISHER, 1984). Section Finzenkogel: submarine proximal pyroclastic flow facies at the flank of a volcanic island at the transition of effusive to explosive eruptions below or above PCL (= pressure compensation level at water depths of ~ 500 m; stadium A and B<sub>1</sub> sensu FISHER, 1984). Section Schleichberg: upper part of a pillow volcano below PCL (stadium A sensu FISHER, 1984).

**Chronostratigraphic age:** Silurian (boundary Llandovery/Wenlock) (SCHÖNLAUB, 1982a).

**Biostratigraphy:** *amorphognathoides* Zone in crinoidal limestone intercalations within tuffitic volcanics as well as limestone intercalations within black schists/lydites below and above the volcanics (SCHÖNLAUB, 1976, 1977a, 1982a).

**Thickness:** 250–300 m at Paarenkogel and Kragelschinken (HIESSLEITNER, 1931). Along the Gößgraben (WSW Trofaiach, ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 132 Trofaiach) the thickness of the entire volcanogenic sequences is between 180 and 550 m. There, the volcanoclastics include also intercalations of schists and up to 150 m thick lavas (SCHLAEGEL-BLAUT, 1990).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lydites, Arkoses, Schists.

**Overlying unit(s):** Crinoidal Limestones (SCHÖNLAUB, 1992) (not shown in ASC 2004).

**Lateral unit(s):** Lydites, Arkoses, Schists.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** Informal working term for thick basic volcanics (first description HIESSLEITNER, 1931) in the hanging parts of the "Lydites, Arkoses, Schists".

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), SCHÖNLAUB & HEINISCH (1993), LOESCHKE & HEINISCH (1993).

## Crinoidenkalke / Crinoidal Limestone

(not shown in ASC 2004)

FRITZ EBNER

**Validity:** Invalid; working term (SCHÖNLAUB, 1976, 1979, 1982a).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK 50-BMN, map sheets 101 Eisenerz and 131 Kalwang).

**Type section:** Not indicated in the literature.

**Reference section(s):** -

**Derivation of name:** After the lithology and the mass occurrence of crinoids.

**Synonyms:** Partim “Crinoiden führende Bänderflaserkalke” (SCHÖNLAUB, 1982a).

**Lithology:** Grey and pink crinoid bearing flaser limestone (SCHÖNLAUB, 1976, 1979, 1982a).

**Fossils:** Crinoids, conodonts.

**Origin, facies:** Shelf deposits (?).

**Chronostratigraphic age:** Llandovery/Wenlock.

**Biostratigraphy:** *amorphognathoides* conodont zone.

**Thickness:** 15 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Volcanics; Polster Quartzites (SCHÖNLAUB, 1992; not illustrated in Text-Fig. 2).

**Overlying unit(s):** Black Lydites, Alaun Schists.

**Lateral unit(s):** Red Sparitic Limestone.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** -

#### Rote Sparitkalke / Red Sparitic Limestone

Fritz Ebner

**Validity:** Invalid; not formalized working term; first description by FLAJS & SCHÖNLAUB (1976).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK-BMN, map sheet 101 Eisenerz).

**Type section:** Ca. 45 m above the bend (N 47°31'44" / E 14°58'03") of the Knappensteig (trail from Präbichl Pass to Leobner Hütte) at the ridge separating the Polsterkar and the Polster S-slope (ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** According to the predominant lithological character.

**Synonyms:** Partim “Silur Transgressionsbildungen” (SCHÖNLAUB, 1977b).

**Lithology:** Pinkish-grey, massive sparry limestone with mm-thick irregular greenish flaser textures in the lower parts and metasomatically mineralized by iron-carbonate (“Rohwand”) in the hanging parts (FLAJS & SCHÖNLAUB, 1976).

**Fossils:** Conodonts.

**Origin, facies:** Transgression deposits.

**Chronostratigraphic age:** Llandovery (SCHÖNLAUB, 1997b).

**Biostratigraphy:** *Icriodina cf. irregularis* and *Distomodus staurogathoides* indicate Aeronian stage (FLAJS & SCHÖNLAUB, 1976).

**Thickness:** 3 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Cystoid Limestone.

**Overlying unit(s):** Orthoceratid Limestone.

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria: Polsterkar in the Eisenerzer Alpen.

**Remarks:** The lower part of the Red Sparitic Limestone is composed of 60 cm sandy shales (FLAJS & SCHÖNLAUB, 1976: Fig. 3).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Orthocerenkalk / Orthoceratid Limestone

Fritz Ebner

**Validity:** Invalid; working term used as local (lithostratigraphic) unit (SCHÖNLAUB, 1982a).

**Type area:** Eisenerzer Alpen, ÖK50-UTM, map sheet 4215 Eisenerz, ÖK50-BMN, map sheet 101 Eisenerz.

**Type section:** Not defined.

**Reference section(s):** -

**Derivation of name:** After the occurrence of orthoceratid nautiloids.

**Synonyms:** Orthocerenkalke der Rotschütt (FLAJS et al., 1963), “Kalke der Handlalm” (FLAJS, 1964, 1967).

**Lithology:** Thick bedded grey – dark grey and rarely pinkish sparry limestones, sometimes with nautiloids.

**Fossils:** Nautiloids, conodonts, crinoids, trilobites, filaments.

**Origin, facies:** Pelagic environment.

**Chronostratigraphic age:** Silurian, (?) Wenlock–Ludlow.

**Biostratigraphy:** *ploeckensis* Zone to *siluricus* Zone (FLAJS et al., 1963; FLAJS, 1964, 1967; FLAJS & SCHÖNLAUB, 1976).

**Thickness:** 24 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Red Sparitic Limestone (FLAJS & SCHÖNLAUB, 1976).

**Overlying unit(s):** Lower Polster Limestone.

**Lateral unit(s):** Black Lydites, Alaun Schists and the “Mischfazies”, an intermediate facies between the Orthoceratid Limestone and the Black Lydites, Alaun Schists (SCHÖNLAUB, 1982a).

**Geographic distribution:** E-GWZ: Styria, Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** TOLLMANN (1977) SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Schwarzer Kieselschiefer, Alaunschiefer / Black Lydites, Alaun Schists

Fritz Ebner

**Validity:** Invalid; working term used as local (lithostratigraphic) unit (SCHÖNLAUB, 1982a).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheets 101 Eisenerz, 131 Kalwang and 132 Trofaiach).

**Type section:** Not defined; typical outcrops are mentioned from the Sauerbrunn- and Weiritzgraben area (HERITSCH, 1931b; HABERFELNER & HERITSCH, 1932a).

**Reference section(s):** -

**Derivation of name:** Derived from the color and lithology.

**Synonyms:** -

**Lithology:** Black siliceous schists, alaun schists, lydites and rare intercalations of black limestones.

**Fossils:** Conodonts in limestone intercalations (FLAJS, 1964, 1967).

**Origin, facies:** Sapropelitic basinal sediments (SCHÖNLAUB, 1982a).

**Chronostratigraphic age:** Silurian (Llandovery–Ludlow).

**Biostratigraphy:** *amorphognathoides*, *sagitta* and *ploeckensis* conodont zones.

**Thickness:** 50–80 m (SCHÖNLAUB, 1982a).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Crinoidal Limestone, Lydites, Arkoses, Schists (SCHÖNLAUB, 1982a).

**Overlying unit(s):** Cavernous Banded Limestone.

**Lateral unit(s):** Intercalations of Black Lydites, Alaun Schists with the Orthoceratid Limestone are named “Mischfazies” (SCHÖNLAUB, 1992).

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** The graptolites described by HERITSCH (1931 b) and HABERFELNER & HERITSCH (1932a) from the Black Lydites, Alaun Schists were recognized as anorganic remains (GRÄF, 1966).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### „Löchrige Bänderkalke“ / Cavernous Banded Limestone

FRITZ EBNER

**Validity:** Invalid; not formalized working term (SCHÖNLAUB, 1977b, 1982a).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not defined.

**Reference section(s):** -

**Derivation of name:** According to holes at the surface of the limestones due the weathering of pyrite.

**Synonyms:** Partim “Bunter Kalk” (SCHÖNLAUB, 1982a).

**Lithology:** Well bedded and platy, grey sometimes reddish, spotted limestone with characteristic, cm-sized holes at the surface.

**Fossils:** Conodonts, rare orthoceratids.

**Origin, facies:** Pelagic facies.

**Chronostratigraphic age:** Upper Silurian (Pridoli).

**Biostratigraphy:** -

**Thickness:** ~ 20 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Black Lydites, Alaun Schists.

**Overlying unit(s):** Flaser Limestone.

**Lateral unit(s):** Lower Polster Limestones.

**Geographic distribution:** E-GWZ; Styria: Eisenerzer Alpen.

**Remarks:** The lithology resembles the upper Silurian “Alticola/Megaerella Limestones” of the Carnic Alps (SCHÖNLAUB, 1977b, 1982a). However, the Cavernous Banded Limestone was also compared with upper Devonian flaser limestones of the Carnic Alps (HABERFELNER, 1935).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Flaserkalk / Flaser Limestones

FRITZ EBNER

**Validity:** Invalid; informal working term (SCHÖNLAUB, 1982a).

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheets 101 Eisenerz and 131 Kalwang).

**Type section:** -

**Reference section(s):** -

**Derivation of name:** According to the lithology.

**Synonyms:** “Erzführender Kalk” (CZERMAK, 1931); “Bunter Flaser-Bänderkalk und geschieferter Kalk” (SCHÖNLAUB, 1982a).

**Lithology:** a) in basal parts subordinate thin platy black limestones; b) variegated flaser- and banded limestones and reddish calcareous schists; c) within (b) occasionally layers of grey organodetritic limestones; d) stocks of meta-somatic siderite-ankerite mineralization.

**Fossils:** Conodonts, *dacryoconarides* (in b); c) crinoids and stromatoporoids.

**Origin, facies:** Pelagic environment; c) allodapic deposits.

**Chronostratigraphic age:** Lower Devonian: a) Lochkovian; b) Pragian–upper Emsian (middle Dalejeum).

**Biostratigraphy:** Based on conodonts.

**Thickness:** a) ~ 30 m; b) 200–250 m; c) 40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Cavernous Banded Limestone, Orthoceratid Limestone.

**Overlying unit(s):** -

**Lateral unit(s):** Lower and Upper Polster Limestone, Sauerberg Limestone, ? Massive Limestone.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Untere Polsterkalke / Lower Polster Limestone

FRITZ EBNER

**Validity:** Invalid; informal working term (FLAJS & SCHÖNLAUB, 1976).

**Type area:** Eisenerzer Alpen, Polster area; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not designated; FLAJS & SCHÖNLAUB (1976) presented a comprehensive description of a section along the track below the material lift from the foot station (N 47°31'52" / E 14°58'29") to the Leobner Hütte (N 47°37'00" / E 14°57'42"), ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** After the mountain Polster (1,910 m; N 47°31'11" / E 14°58'28"), ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN; map sheet 101 Eisenerz).

**Synonyms:** "Untere Polsterkalke" (FLAJS & SCHÖNLAUB, 1976); "Rötlicher Bankkalk vom Typus der Polsterkalke" (SCHÖNLAUB, 1982a).

**Lithology:** At the section mentioned above from bottom to top (FLAJS & SCHÖNLAUB, 1976):

3 m bluish grey to violet sparry limestones (similar to the Silurian Orthoceratid Limestones; some meters of "Rohwand" (= metasomatic ankeritic mineralization) intercalated with 3–4 m greenish and violet schists. The bulk is made up of 45–50 m variegated limestones (light grey to pinkish flamed, ± bedded, weakly banded dense limestone with intercalation of dark, more sparry limestone). In the upper parts 5 m thick "Rohwand" and a band of green schists occur.

**Fossils:** Conodonts.

**Origin, facies:** Pelagic environment.

**Chronostratigraphic age:** (?)uppermost Silurian–lowermost Devonian (Lochkovian).

**Biostratigraphy:** *Icriodus woschmidti* – *I. postwoschmidti* Zone in the upper parts of the unit (FLAJS & SCHÖNLAUB, 1976).

**Thickness:** Around 65–70 m; the upper variegated part: 45–50 m (FLAJS & SCHÖNLAUB, 1976).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Orthoceratid Limestone.

**Overlying unit(s):** Crinoid-Stromatoporeid Limestone.

**Lateral unit(s):** Flaser Limestones.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### **Crinoiden-Stromatoporen-Kalke / Crinoid-Stromatoporeid Limestone**

FRITZ EBNER

**Validity:** Invalid; informal working term (FLAJS & SCHÖNLAUB, 1976).

**Type area:** Eisenerzer Alpen, Polster area, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not designated; FLAJS & SCHÖNLAUB (1976) presented a comprehensive description of a sec-

tion along the track below the material lift from the foot station (N 47°31'52" / E 14°58'29") to the Leobner Hütte (N 47°37'00" / E 14°57'42"), ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** Named after the rock forming fossils.

**Synonyms:** "Crinoiden-Stromatoporen-Horizont" (FLAJS & SCHÖNLAUB, 1976).

**Lithology:** Dm-bedded, light grey and weakly banded limestones made up of recrystallized fragments of stromatoporeids (2–30 cm) within a sparry matrix of crinoidal detritus.

**Fossils:** Stromatoporeids, crinoids, conodonts.

**Origin, facies:** Allodapic limestones.

**Chronostratigraphic age:** Lower Devonian (Lochkovian–(?)Emsian) (FLAJS & SCHÖNLAUB, 1976).

**Biostratigraphy:** -

**Thickness:** 10–40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Polster Limestone (FLAJS & SCHÖNLAUB, 1976); Flaser Limestones.

**Overlying unit(s):** Upper Polster Limestone, Flaser Limestones.

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen, Polster area.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### **Obere Polsterkalke / Upper Polster Limestone**

FRITZ EBNER

**Validity:** Invalid; informal working term (FLAJS & SCHÖNLAUB, 1976).

**Type area:** Eisenerzer Alpen, Polster area, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not designated; FLAJS & SCHÖNLAUB (1976) presented a comprehensive description of a section along the track below the material lift from the foot station (N 47°31'52" / E 14°58'29") to the Leobner Hütte (N 47°37'00" / E 14°57'42"); ÖK50-UTM, map sheet 4215 Eisenerz (ÖK 50-BMN, map sheet 101 Eisenerz).

**Reference section(s):** -

**Derivation of name:** After the mountain Polster (1,910 m; N 47°31'11" / E 14°58'28") in the Präbichl area; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Synonyms:** -

**Lithology:** Light violet and pinkish-violet flaserlimestones and banded limestones with layers of up to 60 cm thick organodetritic (stromatoporeids, crinoids) limestones in their lower parts. The uppermost parts, 4 m thick, consist of grey sparry limestone (FLAJS & SCHÖNLAUB, 1976).

**Fossils:** Conodonts, tentaculites, stromatoporoids, crinoids (FLAJS & SCHÖNLAUB, 1976).

**Origin, facies:** Pelagic basinal environment (FLAJS & SCHÖNLAUB, 1976).

**Chronostratigraphic age:** Lower Devonian (?Pragian) (FLAJS & SCHÖNLAUB, 1976).

**Biostratigraphy:** Based on conodonts.

**Thickness:** 50 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Crinoid-Stromatoporoid Limestone (FLAJS & SCHÖNLAUB, 1976).

**Overlying unit(s):** Permian Präbichl Formation along an angular unconformity.

**Lateral unit(s):** Flaser Limestones, Sauberg Limestone.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen, Präbichl area.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Sauberg-Kalk / Sauberg Limestone

FRITZ EBNER

**Validity:** Invalid; not formalized.

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Sauberg quarry, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz) at former Erzberg SSW slope. This locality does not exist anymore due to siderite mining.

**Reference section(s):** -

**Derivation of name:** According to the former Sauberg quarry at the Erzberg.

**Synonyms:** "Sauburger Kalk" (STUR, 1866); "Erzführender Kalk" (CZERMAK, 1931).

**Lithology:** Thick bedded, light to pinkish, red mottled limestone.

**Fossils:** Corals, gastropods, bivalves, nautiloids, trilobites (scutellids), brachiopods (STUR, 1865, 1866; HERITSCH, 1931a; CZERMAK, 1931), conodonts (SCHÖNLAUB et al., 1980).

**Origin, facies:** Carbonate shelf environment.

**Chronostratigraphic age:** Upper Lower Devonian (upper Pragian–Zlichovian; SCHÖNLAUB, 1979; SCHÖNLAUB et al., 1980).

**Biostratigraphy:** Based on conodonts.

**Thickness:** 70–150 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flaser Limestones.

**Overlying unit(s):** Flaser Limestones.

**Lateral unit(s):** Flaser Limestones, Upper Polster Limestone.

**Geographic distribution:** E-GWZ; Eisenerzer Alpen.

**Remarks:** Historical term for pinkish red mottled fossiliferous limestones first named by STUR (1865, 1866) from the Erzberg. Later this term was often used as synonym for Lower Devonian reddish mottled flaser limestones in the Eisenerzer Alpen.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989).

### Massenkalk / Massive Limestones

FRITZ EBNER

**Validity:** Invalid; informal working term.

**Type area:** Eisenerzer Alpen, ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheets 101 Eisenerz, 132 Trofaiach).

**Type section:** Not indicated.

**Reference section(s):** -

**Derivation of name:** According to the massive lithological character.

**Synonyms:** Partim "Erzführende Kalke" (STACHE, 1874); "Heller Bänderkalk der Reitingdecke" (SCHÖNLAUB, 1982a).

**Lithology:** Massive and sometimes banded limestones.

**Fossils:** Heliolitids, Syringoporids, stromatoporoids, conodonts (HERITSCH, 1927b; HABERFELNER, 1935; SCHÖNLAUB, 1979).

**Origin, facies:** Shallow water "reef" facies.

**Chronostratigraphic age:** Devonian (?Middle Devonian).

**Biostratigraphy:** -

**Thickness:** -

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flaser Limestones.

**Overlying unit(s):** -

**Lateral unit(s):** Flaser Limestones.

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** Formerly, the massive limestones were attributed to a Middle Devonian reef facies. However, all conodont data constrain an Early Devonian age. Middle Devonian was only dated from one limestone layer from level "Dreikönig" at Erzberg which was later removed by mining activities. Nevertheless, it is suggested that Middle Devonian could be represented by massive banded limestones of the Reiting Nappe at some localities of the Eisenerzer Alpen (e.g., Linseck, HÖchstein, Stadelstein, Schwarzenstein; SCHÖNLAUB, 1982a: p. 394).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Plattenkalk / Platy Limestone

FRITZ EBNER

**Validity:** Invalid; informal working term (SCHÖNLAUB, 1979).

**Type area:** Eisenerzer Alpen; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Kalkschuppe at Erzberg.

**Reference section(s):** -



**Derivation of name:** After the lithological character.

**Synonyms:** -

**Lithology:** Grey, splintery breaking, hard, well bedded limestone.

**Fossils:** Very rare and badly preserved undeterminable conodonts (SCHÖNLAUB, 1979).

**Origin, facies:** Carbonatic shelf deposits.

**Chronostratigraphic age:** ?Middle Devonian.

**Biostratigraphy:** -

**Thickness:** 50 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flaser Limestones (Lower Devonian).

**Overlying unit(s):** Flaser Limestones (Upper Devonian).

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** The rare and badly preserved conodonts are undeterminable. Dating is due to the position between conodont dated Lower and Upper Devonian Flaser Limestones (SCHÖNLAUB, 1979, 1980a).

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1982a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Flaserkalke / Flaser Limestones

FRIITZ EBNER

**Validity:** Invalid; informal working term (SCHÖNLAUB et al., 1980).

**Type area:** Eisenerzer Alpen; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not indicated.

**Reference section(s):** -

**Derivation of name:** After the lithological character.

**Synonyms:** -

**Lithology:** Light grey to whitish and reddish indistinctly to well bedded limestones.

**Fossils:** Badly preserved conodonts (FLAJS, 1967b).

**Origin, facies:** Basinal, pelagic facies.

**Chronostratigraphic age:** Upper Devonian (Frasnian-lower Famennian).

**Biostratigraphy:** Some distinct morphological features of the genus *Palmatolepis* indicate lower Upper Devonian, the occurrence of *Ancyrodella* Frasnian (FLAJS, 1967a; SCHÖNLAUB, 1982a).

**Thickness:** 10 m (SCHÖNLAUB, 1982a).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Platy Limestones.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** Devonian limestones younger than early Famennian are not known from the Eisenerzer Alpen. How-

ever, conodonts of this interval are known from limestone pebbles in the early Carboniferous Crinoidal Limestone Breccia.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

#### Crinoidenkalkbreckie / Crinoidal Limestone Breccia

FRIITZ EBNER

**Validity:** Invalid; informal working term (SCHÖNLAUB, 1979; SCHÖNLAUB et al., 1980).

**Type area:** Eisenerzer Alpen; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz).

**Type section:** Not indicated; some sections are described from the mining levels Schuchart, Dreikönig, Antoni and Liedemann from the Erzberg (SCHÖNLAUB, 1979; SCHÖNLAUB et al., 1980).

**Reference section(s):** See above.

**Derivation of name:** -

**Synonyms:** "Kalkbreckie des Unterkarbons" (SCHÖNLAUB, 1982a).

**Lithology:** Banded brecciated limestone with components (maximum diameter: 15 cm) of light to dark grey, often sparry, tectonically flattened limestone in a matrix of crinoidal debris. At one site sparry pure crinoidal limestone is situated below the limestone breccia. Dense banded to phacoidal limestones with a mixed fauna of Devonian-lower Carboniferous conodonts occur as thin tectonic slices at the base of the Eisenerz Formation (SCHÖNLAUB et al., 1980).

**Fossils:** Conodonts (stratigraphically mixed faunas), crinoids.

**Origin, facies:** The onset of a marine transgression after an erosional gap due to karstification (EBNER, 1991).

**Chronostratigraphic age:** Formation of the breccia occurred during the Viséan. The reworked components indicate Devonian and lowermost Carboniferous.

**Biostratigraphy:** Breccia formation: *Gnathodus bilineatus* Zone; the reworked components indicate *asymmetricus*-, *(?)triangularis*-, *(?)crepida*-, *rhochoidea*-, *marginifera*-, *styriacus*-, *costatus/praesulcata*-, *sulcata*-, *duplicata*-, *(?)sandbergi*- and *anchoralis* zones of Upper Devonian and lower Carboniferous (SCHÖNLAUB, 1982a; SCHÖNLAUB et al., 1980).

**Thickness:** Maximum 10 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Sauberg Limestone, Flaser Limestones (erosional disconformity).

**Overlying unit(s):** Eisenerz Formation.

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** THALMANN (1974) mentioned lower Carboniferous limestones from the Erzberg for the first time. Although any further information is lacking these limestones most probably correspond with the Crinoidal Limestone Breccia.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989, 2008), SCHÖNLAUB & HEINISCH (1993).

### Eisenerz-Formation / Eisenerz Formation

FRITZ EBNER

**Validity:** Invalid; first description (SCHÖNLAUB, 1979; SCHÖNLAUB et al., 1980) used in terms of a formation, but not formalized.

**Type area:** Eisenerzer Alpen; ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheets 101 Eisenerz and 131 Kalwang).

**Type section:** Not indicated.

**Reference section(s):** -

**Derivation of name:** After the town Eisenerz situated near to the Styrian Erzberg, ÖK50-UTM, map sheet 4215 (ÖK50-BMN, map sheet 101 Eisenerz).

**Synonyms:** "Eisenerzer Schichten" (SCHÖNLAUB, 1979, 1982a; SCHÖNLAUB et al., 1980); "Grenzschiefer" (VACEK, 1903); "Zwischenschiefer" (JUNGWIRTH & LACKENSCHWEIGER, 1922).

**Lithology:** Grey, partly graphitic schists with intercalations of greyish-green to violet schist, sandy schists, thin bedded to platy brownish grey sandstone, black lydite and siliceous schists (SCHÖNLAUB, 1979, 1982a; SCHÖNLAUB et al., 1980). Often the schists are laminated and convolute bedding is locally present.

The Eisenerz Formation can be divided into two parts: at the bottom "oil" green sericite-quartzite schists occur, followed by schists, rich in graphite (HAJEK, 1966: p. 26, 27; SCHÖNLAUB et al., 1980). The inclusion of porphyroids (HAJEK, 1966) has not been confirmed later (SCHÖNLAUB et al., 1980). Most probably they form tectonic slices of porphyroidic materials (SCHÖNLAUB et al., 1980).

**Fossils:** -

**Origin, facies:** Probably fine clastic basinal environment.

**Chronostratigraphic age:** Unclear, but it should be younger than the Visean Crinoidal Limestone Breccia. However, a late Carboniferous age cannot be excluded (SCHÖNLAUB et al., 1980).

**Biostratigraphy:** -

**Thickness:** Approx. 80 m at the Erzberg (SCHÖNLAUB et al., 1980) and 100–150 m maximum at other localities (SCHÖNLAUB, 1982a). Mostly the thickness is tectonically reduced and sometimes the Eisenerz Formation is even missing (e.g., at the contact of Variscan nappe structures).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Crinoidal Limestone Breccia.

**Overlying unit(s):** At Erzberg this unit forms the top of the "Liegendscholle" which is superposed due to Variscan Nappe tectonics by Silurian/Devonian limestones of the "Hangendscholle" (SCHÖNLAUB et al., 1980).

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** The outcrops described at Erzberg (SCHÖNLAUB et al., 1980) do not exist anymore due to mining operations.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1980a), EBNER et al. (1989), SCHÖNLAUB & HEINISCH (1993).

### Radschiefer / Rad Schists

FRITZ EBNER

**Validity:** Invalid; not formalized, but used in terms of a formation since NIEVOLL (1983, 1987).

**Type area:** ÖK50-UTM, map sheet 4211 Neuberg an der Mürz (ÖK50-BMN, map sheet 103 Kindberg).

**Type section:** Not indicated. Detailed descriptions (NIEVOLL, 1983, 1987) derive from the section of the Steinbachgraben valley approx. 5.5 km NW Veitsch, ÖK50-UTM, map sheet 4211 Neuberg an der Mürz (ÖK50-BMN, map sheet 103 Kindberg).

**Reference section(s):** -

**Derivation of name:** After "Rad" which is a field name but also the name of a former inn (Radwirt; N 47°36'55" / E 15°27'14") in the Veitschbach valley, ÖK50-UTM, map sheet 4211 Neuberg an der Mürz (ÖK50-BMN, map sheet 103 Kindberg).

**Synonyms:** "Radschieferserie" (CORNELIUS, 1952a), "Rad Phyllit" (NEUBAUER et al., 1994), Rad subunit (NIEVOLL, 1983, 1987).

**Lithology:** Monotonous dark grey, quartzitic phyllite; at the base intercalation of < 10 m coarse grained sandstones with detritus deriving from the Blasseneck Porphyry (NIEVOLL, 1983, 1987).

**Fossils:** Slightly calcareous metasiltstones close to the base include badly preserved fossils (cystoideans, bryozoans, brachiopods/bivalves) (NIEVOLL, 1983, 1987).

**Origin, facies:** Fine clastic basinal environment.

**Chronostratigraphic age:** Uppermost Ordovician (Katian)–Lower Devonian (NIEVOLL, 1983, 1987).

**Biostratigraphy:** The age is constrained by the position above the Blasseneck Porphyry and conodonts of the overlying Metalliferous Limestone (EBNER, 1973, 1974; NIEVOLL, 1983, 1987).

**Thickness:** 400 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Sedimentary contact to the Blasseneck Porphyry.

**Overlying unit(s):** Metalliferous Limestones (NIEVOLL, 1983, 1987).

**Lateral unit(s):** The fossiliferous siltstones at the base of the Rad Schists as well as the sandstones with porphyroidic detritus imply a correlation of the basal parts with the Polster Quartzite and the Peterbaumgraben Formation.

**Geographic distribution:** E-GWZ; Styria, ÖK50-UTM, map sheet 4211 Neuberg an der Mürz, ÖK50-UTM, map sheet 4212 Mürzzuschlag (ÖK50-BMN, map sheet 103 Kindberg).

**Remarks:** After the first description of CORNELIUS (1952a) the Rad Schists were subdivided by NIEVOLL (1983, 1987) into the Rad and the Stocker subunits. Both units are overlain by Metalliferous Limestones. Since the correlation between both units remains problematic the description above is restricted to the Rad unit only.

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a, 2001), EBNER et al. (1989), HEINISCH & SCHÖNLAUB (1993).

### Erzführende Kalke / Metalliferous Limestones

FRITZ EBNER

**Validity:** Invalid; general working term for not subdivided Devonian limestones in the E-GWZ.

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK 50-BMN, map sheets 101 Eisenerz and 131 Kalwang), ÖK50-UTM, map sheet 4211 Neuberg an der Mürz (ÖK50-BMN, map sheet 103 Kindberg).

**Type section:** -

**Reference section(s):** -

**Derivation of name:** After siderite-ankerite mineralizations which are frequently hosted by mainly Devonian limestones (CZERMAK, 1931; TOLLMANN, 1977; WEBER, 1997a, b).

**Synonyms:** See remarks.

**Lithology:** Variegated bedded flaser limestones hosting irregular metasomatic stocks of siderite and ankerite mineralizations (WEBER, 1997a, b).

**Fossils:** See remarks.

**Origin, facies:** See remarks.

**Chronostratigraphic age:** Devonian; see remarks.

**Biostratigraphy:** See remarks.

**Thickness:** See remarks.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** -

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Eisenerzer Alpen.

**Remarks:** Since the beginning of geologic research in the E-GWZ (STUR, 1865, 1866) the general term Metalliferous Limestones was used cumulatively for mainly Devonian limestones which include irregular stocks of metasomatic iron mineralizations. Later parts of these limestones, especially in the Eisenerzer Alpen, were assigned as informal lithostratigraphic units (SCHÖNLAUB 1979, 1980a, 1982a, b; FLAJS & SCHÖNLAUB, 1976). In the Veitsch area of the E-GWZ (ÖK50-UTM, map sheet 4211 Neuberg an der Mürz; ÖK50-BMN, map sheet 103 Kindberg) isolated outcrops of Metalliferous Limestones above the Rad Schists (NIEVOLL, 1983, 1987) yielded conodont faunas representing the entire Devonian period (EBNER, 1973, 1974; NIEVOLL 1983, 1987).

**Complementary references:** TOLLMANN (1977), EBNER et al. (1989), HEINISCH & SCHÖNLAUB (1993).

### Veitsch Nappe

In the ASC 2004 the stratigraphic sequence of the Veitsch Nappe is shown in the Tournaisian to Moskavian parts of the column "E-Grauwackenzone" (E-Greywacke Zone) right of the Eisenerz Formation.

The Veitsch Nappe is situated in the E-GWZ (Styria, Lower Austria) at the tectonic footwall of the Greywacke Zone and is composed of Carboniferous (lower Visean–Moskavian) marine shallow water sediments. They were only affected by Alpine (Cretaceous) deformation and low grade metamorphism (RATSCHBACHER, 1984, 1987; NEUBAUER et al., 1994; RANTITSCH et al., 2004; EBNER et al., 2007, 2008). NEUBAUER et al. (1994) proposed to summarize these sediments within the Veitsch Group (not shown in the ASC 2004).

In the western part of the E-GWZ the sequence of the Veitsch Nappe was formerly subdivided into three formations: Steilbachgraben Formation, Triebenstein Formation, and Sunk Formation (RATSCHBACHER, 1984). In a restricted area SE Kapfenberg the Sunk Formation is superposed by (?) Permian ochre shales and sandstones (= Graschnitz Formation; NEUBAUER, 1983; NEUBAUER et al., 1994). It is not clear if RATSCHBACHER's subdivision into formations is also applicable for the eastern parts of the Veitsch Nappe. Nevertheless, magnesite and dark clastic sediments rich in graphite and plants resembling the Sunk Formation also occur in the eastern parts of the Veitsch Nappe. Especially in the magnesite deposit of Veitsch dolomites and clastics below the magnesite are rich in fossils (corals, brachiopods, crinoids, trilobites, gastropods, agglutinated foraminifers, spicula, ostracods; KOCH, 1893; KLEBELSBERG, 1927; HERITSCH, 1928a, 1930a; METZ, 1937; FELSER & FLÜGEL, 1975; HAHN & HAHN, 1977; KRÄINER, 1992). Trilobites indicate lower Visean (HAHN & HAHN, 1977) and corals upper Visean *Dibunophyllum* Zone (FELSER & FLÜGEL, 1975; FELSER, 1977), however, a correlation with the sequence of Hohentauern/Sunk is problematic.

The abundance of magnesite and graphite is also responsible to assign some parts of the Veitsch Nappe as the "Magnesite Carboniferous" (EBNER, 1997) and the "Graphite Carboniferous" (e.g., HAMMER, 1924). The Carboniferous of the Veitsch Nappe represents post-orogenic sediments (in relation to an early Carboniferous [= Bretonic] tectonic phase) deposited in a shallow marine foredeep (FLÜGEL, 1977; NEUBAUER & VOZAROVA, 1990; EBNER, 1992; EBNER et al., 1991, 2007, 2008). The metasomatic magnesite deposits, all most probably situated in the Steilbachgraben Formation or its equivalents, form the Veitsch Nappe magnesite (talca) district. The Sunk Formation hosts the Veitsch Nappe graphite district (WEBER, 1977a, b).

### Steilbachgraben-Formation / Steilbachgraben Formation

FRITZ EBNER

**Validity:** Valid; formal description by RATSCHBACHER (1984).

**Type area:** Rottenmanner Tauern; ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Type section:** Overlapping parts of the type section are situated around the abandoned magnesite mine NW of Hohentauern (N 47°26'53" / E 14°27'59"). Sections 8–11 (RATSCHBACHER, 1984: Figs. 1–3) are situated at the NE-ridge of Sunkmauer (altitude 1,180 m), the southern margin of the magnesite open pit, in the upper Steilbachgraben (N 47°26'22" / E 14°29'57" to N 47°26'26" / E 14°30'06") and within the magnesite open pit.

**Reference section(s):** -

**Derivation of name:** After the Steilbachgraben (N 47°26'22" / E 14°29'57" to N 47°26'26" / E 14°30'06") NE of Hohentauern (N 47°26'04" / E 14°29'01"), ÖK50-UTM, map sheet 4214 Trieben (ÖK 50-BMN, map sheet 130 Trieben).

**Synonyms:** Steilbach Formation in the ASC 2004. "Magnesit Karbon" (EBNER, 1997) according to the magnesite deposits in the Steilbachgraben Formation. The sparry magnesite of the Veitsch Nappe is known in the international mineral deposits' literature as "Veitsch type magnesite" (EBNER et al., 2004a, b).

**Lithology:** Fine grained clastics with intercalations of sandstone and layers/lenses of grey, bedded limestones and dolomites. Lenses and irregular stocks of sparry magnesite are included in the dolomitic parts. Intercalations of volcanic layers (metatuffs) derived from tholeiitic intraplate basalts occur outside the type area (PROCHASKA & EBNER, 1989). Some layers of gypsum and anhydrite are known from clastic sediments closely related to the magnesite deposits of Hohentauern (PETRASCHECK, 1978) and Oberdorf (SCHROLL et al., 1989).

**Fossils:** Corals, brachiopods, crinoids, trilobites, gastropods, agglutinated foraminifers, spicula, ostracods especially from the Hohentauern area and the abandoned magnesite mine in Veitsch (ÖK50-UTM, map sheet 4211 Neuberg an der Mürz, ÖK50-BMN, map sheet 103 Kindberg) (HERITSCH, 1907, 1917a, 1933a; KLEBELSBERG, 1927; KOCH, 1893; FELSER, 1977; HAHN & HAHN, 1977; KRÄINER, 1992, 1993a).

**Origin, facies:** Shallow marine, mixed siliciclastic-carbonatic shelf environment formed in a marine foredeep (molasse) environment after an early Carboniferous orogeny (FLÜGEL, 1977; KRÄINER, 1992; EBNER, 1992; EBNER et al., 2007, 2008).

**Chronostratigraphic age:** Lower Carboniferous (?Tournaisian–upper Visean).  $\delta^{34}\text{S}$  values of gypsum/anhydrite intercalations indicate Carboniferous ages (PETRASCHECK, 1978; SCHROLL et al., 1989).  $^{86}\text{Sr}/^{87}\text{Sr}$  ratios from limestones are increased relative to the Visean seawater curve (EBNER et al., 2008; AZIM-ZADEH et al., 2008).

**Biostratigraphy:** Trilobites indicate the lower Visean (HAHN & HAHN, 1977) and corals upper Visean *Dibunophyllum* Zone (H. FLÜGEL, 1975; FELSER, 1977).

**Thickness:** Up to 230 m.

**Lithostratigraphically higher rank unit:** Veitsch Group (NEUBAUER et al., 1994).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Middle Austroalpine Crystalline unit (tectonic contact) (TOLLMANN, 1977; RANTITSCH et al., 2004; NEUBAUER et al., 1994).

**Overlying unit(s):** Triebenstein Formation.

**Lateral unit(s):** Clastic sediments (RATSCHBACHER, 1984, 1987) and other parts of the "Magnesite Carboniferous".

**Geographic distribution:** E-GWZ; Styria, Lower Austria.

**Remarks:** In ASC 2004 this formation is wrongly named "Steilbach-Formation" instead of Steilbachgraben Formation.

**Complementary references:** SCHÖNLAUB (1979, 1980a), EBNER et al. (1989, 1991), KRÄINER (1993a), EBNER & PROCHASKA (2001).

## Triebenstein-Formation / Triebenstein Formation

FRITZ EBNER

**Validity:** Valid; first nomination by RUMPF (1874), formal description by RATSCHBACHER (1984).

**Type area:** Rottenmanner Tauern, ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Type section:** At mountain Triebenstein (N 47°26'43" / E 14°29'14") north of Hohentauern (N 47°26'04" / E 14°29'01"). Section 7 (RATSCHBACHER, 1984: Fig. 3) represents only a small part (~ 60 m) of the formation.

**Reference section(s):** -

**Derivation of name:** After the mountain Triebenstein (N 47°26'43" / E 14°29'14") north of Hohentauern (N 47°26'04" / E 14°29'01"), ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Synonyms:** "Triebensteinkalk" in the older literature (HERITSCH, 1933a; TOLLMANN, 1977) before formalization by RATSCHBACHER (1984); "Triebensteinkalkmarmor" (RATSCHBACHER, 1984).

**Lithology:** Bedded, partly fossiliferous limestone marbles with metapelitic and rare metapsammitic/psephitic intercalations. Locally lenses of pure limestone marbles of greater thickness (RATSCHBACHER, 1984).

**Fossils:** Crinoids, corals, brachiopods, bivalves in the lower parts (HERITSCH, 1908, 1917a, 1933a).

**Origin, facies:** Carbonatic shelf facies interfingering with individual bioherms.

**Chronostratigraphic age:** Uppermost Visean–Serpukhovian.

**Biostratigraphy:** Lower parts within the *Dibunophyllum* Zone (HERITSCH, 1933a; FELSER, 1977).

**Thickness:** 35–300 m (RATSCHBACHER, 1984).

**Lithostratigraphically higher rank unit:** Veitsch Group (NEUBAUER et al., 1994)

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Steilbachgraben Formation (note typological error "Steilbach-Formation" in the ASC 2004).

**Overlying unit(s):** Sunk Formation.

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria, Rottenmanner Tauern.

**Remarks:** -

**Complementary references:** TOLLMANN (1977), SCHÖNLAUB (1979, 1980a), EBNER et al. (1989, 1991, 2007, 2008), KRÄINER (1992, 1993a), EBNER & PROCHASKA (2001).

## Sunk-Formation / Sunk Formation

FRITZ EBNER

**Validity:** Valid; formal description by RATSCHBACHER (1984).

**Type area:** Rottenmanner Tauern, ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Type section:** Sections 1–6 (RATSCHBACHER, 1984: Fig. 3) around the abandoned graphite mine Sunk (N 47°27'49" / E 14°28'29") 3.4 km N of Hohentauern (N 47°26'04" / E 14°29'01"), ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Reference section(s):** -

**Derivation of name:** After the valley “Sunk” N of Hohentauern between (N 47°27'12" / E 14°28'11") and the Triebenbachtal (N 47°27'45" / E 14°29'08"), ÖK50-UTM, map sheet 4214 Trieben (ÖK50-BMN, map sheet 130 Trieben).

**Synonyms:** “Graphitführende Serie des Oberkarbon” (HERITSCH, 1911); “Graphitkarbon” (HAMMER, 1924).

**Lithology:** Coarsening upward sequence of graphitic metapelites, -psammities and -psephites, locally with thin carbonate intercalations with debris of bivalves and crinoids. Lenses of graphite are intercalated at several localities.

**Fossils:** Plant fossils are concentrated in some localities from Semmering in the E as far as to Lassing in the W (TOULA, 1877; GLAESSNER, 1935; JONGMANS, 1938; VAN AMERON & BOERSMA, 1974).

**Origin, facies:** River dominated delta facies near to a regressive shoreline with distributary bay deposits and channel fillings (RATSCHBACHER, 1984, 1987; KRAINER, 1992, 1993a).

**Chronostratigraphic age:** Bashkirian–Moskovan (TENCHOV, 1980; KRAINER, 1993a).

**Biostratigraphy:** Stratigraphic important floral elements: *Alethopteris lonchitica* (main occurrence Westfalian A); *Alethopteris decurrens* and *Neuropteris heterophyllia* (upper Westfalian A–lower Westfalian C); *Sphenophyllum cuneifo-*

*lium* (extinction in lower Westfalian C); *Linopteris cf. regniezii* (Westfalian C) (STUR, 1871, 1883; JONGMANS, 1938; VAN AMERON & BOERSMA, 1974; TENCHOV, 1980; WAGNER, 1984; KRAINER, 1992).

**Thickness:** 50–150 m.

**Lithostratigraphically higher rank unit:** Veitsch Group (NEUBAUER et al., 1994).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Triebenstein Formation.

**Overlying unit(s):** Only at one locality (?) Permian pinkish metaclastics (Graschnitz Formation; NEUBAUER, 1983); in other localities tectonic contact to the higher Alpine thrust units/sheets of the Greywacke Zone (NEUBAUER et al., 1994).

**Lateral unit(s):** -

**Geographic distribution:** E-GWZ; Styria to Lower Austria.

**Remarks:** The formation includes the operating graphite mine of Kaisersberg (N 47°20'05" / E 14°58'29"), ÖK50-UTM, map sheet 4221 Knittelfeld (ÖK50-BMN, map sheet 132 Trofaiach) and other abandoned graphite operations of the Graphite district Veitsch Nappe (EBNER, 1997; WEBER, 1997a, b).

**Complementary references:** TOLLMANN (1977), BERGER (1950), SCHÖNLAUB (1979, 1980a), EBNER et al., (1989, 1991, 2007, 2008), EBNER & PROCHASKA (2001).

## Gurktaler Deckensystem / Gurktal Nappe System

The Gurktal Nappe System contains Ordovician to lower Carboniferous basement sequences and upper Carboniferous to Triassic, and Upper Cretaceous to Paleogene cover sequences. In general, the nappe complex is subdivided into two major tectonic units, the lower, low grade metamorphic Murau Nappe and the higher, very low to low grade metamorphic Stolzalpe Nappe. Both nappes contain Lower Paleozoic successions with similar stratigraphic trends but striking differences in detail (FLÜGEL & NEUBAUER, 1984; NEUBAUER & PISTOTNIK, 1984). Additionally, a nappe of medium grade metamorphics (Ackerl Nappe) occurs in the uppermost structural position (GOSEN et al., 1985; NEUBAUER & PISTOTNIK, 1984).

### Murau Nappe

The basal sequence of the Murau Nappe consists of phyllites with prasinites and greenschists derived from lava flows, sills and tuffs which are overlain by a phyllite-rich unit.

Carbonatic phyllites, black phyllites, and quartzites with minor greenstones and orthoquartzites build up the next higher stratigraphic unit; at the southern border of the Gurktal Nappe System widespread acidic volcanoclastics occur. The overlying sequence is characterized by laterally differentiated upper Silurian to Lower Devonian carbonates.

### Stolzalpe Nappe

Basal parts of the Stolzalpe Nappe are almost similar to those of the Murau Nappe consisting of mafic volcanic sequences. These sequences are divided into the Middle to Upper Ordovician Magdalensberg Group and the Nock Group which represents the Upper Ordovician followed by the volcanic lower to middle Silurian Eisenhut Group at the

northern edge of the Gurktal Nappe System. These volcanic successions are overlain by sequences dominated by pelitic-psammitic rocks passing into pelagic deposits at the top.

The Gurktal Nappe System is tectonically underlain by Middle Austroalpine units (sensu TOLLMANN, 1977).

### Magdalensberg-Gruppe; Kaser-Gruppe; „Metadiabase“ / Magdalensberg Group; Kaser Group; “Metadiabase”

THOMAS J. SUTTNER

**Validity:** Invalid; first observed by ROSTHORN & CANAVAL (1853); further paleontological and sedimentological research by KAHLER (1953), RIEHL-HERWIRSCH (1970), REITZ (1994) and THIEDIG (2005).

**Type area:** ÖK50-UTM, map sheets 3106 Radenthein, 4102 Althofen, 4107 Klagenfurt, 4108 Sankt Veit an der Glan (ÖK50-BMN, map sheets 184 Ebene Reichenau, 186 Sankt Veit an der Glan, 202 Klagenfurt, 203 Maria Saal).

**Type section:** -

**Reference section(s):** Magdalensberg south of St. Paul (N 46°43'38" / E 14°25'45"), Paule Quarry which is located approx. 1.5 km northeast of St. Donat, Christofberg near Brückl (N 46°42'40" / E 14°28'53"), exposures along the road between Brückl and St. Veit an der Glan (all outcrops show parts of the Magdalensberg Group); Frauenalpe (locality where the “Metadiabasserie” is outcropping; compare THURNER, 1931); north of Gesgeralm (N 46°55'13" / E 13°54'07"), western cliffs of Engeleriegel, outcrops near the Michelealm, southwest of Lake Zelin, northwest of the Rapitzsattel and the Speikkofel (latter six localities expose deposits of the Kaser Group).

**Derivation of name:** After Magdalensberg (KAHLER, 1953: p. 12).

**Synonyms:** Kalktrapp und dioritischer Porphy (ROSTHORN & CANAVAL, 1853); grüne Schiefer (LIPOLD, 1856a); paläozoische Grauwackenschiefer und Diabasgesteine (BECK, 1931); Mandelgesteine und Lockergesteine (KAHLER & WOLFSEGGGER, 1934); Magdalensbergserie (RIEHL-HERWIRSCH, 1970); Magdalensberg-Folge [partim] (THIEDIG, 2005).

**Lithology:** Phyllitic shale, conglomerate layers; pillow lavas; greenish and purple tuffs, ferruginous dolomitic tuffs with carbonatic lenses, lydites.

**Fossils:** An overview of the fauna is provided by RIEHL-HERWIRSCH (1970) who listed bryozoans, chitinozoans (see also GROSCHOPF, 1970), conodonts, graptolites, ostracods, radiolarians and scolecodonts. Macrofossils from the Magdalensberg Group are brachiopods obtained by SEELMEIER (1939, 1940) and HAVLICEK et al. (1987). Acritarchs were described by REITZ (1994).

**Origin, facies:** Submarine stratovolcano(s).

**Chronostratigraphic age:** Floian–Darrwilian (?).

**Biostratigraphy:** According to the acritarch assemblage Early to Middle Ordovician age is suggested for the Lower Magdalensberg Group by REITZ (1994).

**Thickness:** > 500 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** Following REITZ (1994), the Magdalensberg Group is divided into a Lower Magdalensberg Group (dominated by clastic rocks) and Upper Magdalensberg Group (dominated by volcanic rocks). This subdivision follows earlier discriminations of KAHLER (1953), RIEHL-HERWIRSCH (1970) and GROSCHOPF (1970).

**Underlying unit(s):** -

**Overlying unit(s):** Golzeck Formation, Schattloch Phyllites, Nock Group; “Gurktal Quartzphyllite Complex”.

**Lateral unit(s):** -

**Geographic distribution:** Carinthia, highland east of Magdalensberg between St. Christoph and Brückl (RIEHL-HERWIRSCH, 1970), in the surrounding of Bleiburg and at the border to Slovenia at St. Georgen (compare REITZ, 1994).

**Remarks:** -

**Complementary references:** PETERS (1855), MURBAN (1938), FRITSCH et al. (1960), STREHL (1962), FRITSCH (1969), BUCHROITHNER (1979), NEUBAUER (1979), SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984), GOSEN et al. (1985), MULFINGER (1988), LOESCHKE (1989a), PISTOTNIK (1989), HOLZER & GORITSCHNIG (1997), KETTRUP (1998).

### Golzeck-Formation / Golzeck Formation

THOMAS J. SUTTNER

**Validity:** Valid; the unit is well described as “Golzeck-Schiefer” by NEUBAUER (1979), but the name Golzeck Formation first appears on the scheme of SCHÖNLAUB (1992: Fig. 13, p. 399).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** The type section is located south of Murau in the Auen area (N 47°02'31" / E 14°09'23"; N 47°02'37" / E 14°09'28"; N 47°02'26" / E 14°09'25") near the Haid-

er farmstead along a forest road (NEUBAUER, 1979: Fig. 2, p. 460).

**Reference section(s):** -

**Derivation of name:** After Mount Golzeck (in the Auen area).

**Synonyms:** Arkosenschiefer (THURNER, 1958); Golzeck-Schiefer (NEUBAUER, 1979).

**Lithology:** grey to greyish green shale, metapsammities, phyllitic shale, ferruginous dolomite (NEUBAUER, 1979: p. 459).

**Fossils:** Conodonts, crinoids.

**Origin, facies:** Marine deposits consisting of weathering products of acidic volcanites and metamorphic areas (compare NEUBAUER, 1984: Fig. 17, p. 56); phyllitic unit.

**Chronostratigraphic age:** Middle–Late Ordovician (NEUBAUER, 1979).

**Biostratigraphy:** Among six conodont taxa described from this unit (compare NEUBAUER, 1979), fragments assigned to *Amorphognathus?* sp. indicate Late Ordovician. Based on the assemblage provided by NEUBAUER (1979), no further assignment can be made, which would constrain the unit to a distinctive biostratigraphic zone.

**Thickness:** > 100 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Magdalensberg Group, Kaser Group, “Metadiabase”.

**Overlying unit(s):** Golzeck Porphyry (conformable contact).

**Lateral unit(s):** Schattloch Phyllites (conformable contact).

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** NEUBAUER (1979) distinguished three groups within the Lower Paleozoic sequence of the Gurktal Nappe: the Auen Group, Pranker Group and Murau Group. Within the Auen Group (compare Text-Fig. 3) mainly carbonatic units (Lower Auen Dolomite, Middle Auen Dolomite, Haider Marble and Upper Auen Dolomite) together with shales (Golzeck Formation) and magmatic deposits (Golzeck Porphyry) are lumped.

**Complementary references:** SCHÖNLAUB (1979), NEUBAUER & PISTOTNIK (1984), GOSEN et al. (1985).

### Golzeck-Porphyr / Golzeck Porphyry

THOMAS J. SUTTNER

**Validity:** Invalid; first mapped by GEYER (1891a, b); well described by NEUBAUER (1979).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Section in the vicinity of Haid-er farmstead located south of Murau in the Auen area (N 47°02'27" / E 14°09'24").

Time Scale			Auen Group (NEUBAUER, 1979)	Pranker Group (NEUBAUER, 1979)	Murau Group (NEUBAUER, 1979)	Althofen Group (SCHÖNLAUB, 1971c)	
DEVONIAN	U	Famennian	15.3			Upper Althofen Formation	
		Frasnian	10.8	Upper Auen Dolomite		Althofen Limestone Breccia ?	
	M	Givetian	6.5				
		Eifelian	5.7		Ursch Dolomite	Reef-debris limestones of Althofen	
	L	Emsian	9.5	Haider Marble			Lower Althofen Limestone
		Pragian	4.2				
		Lochkovian	4.8		Pranker Metaclastics		
	SILURIAN	Pr		2.7	Middle Auen Dolomite	Murau Group	
		Wep- lock	Ludfordian Gorstian	4.2			
			Homerian Sheinwoodian	5.5			
Llandoverly		Telychian					
		Aeronian Rhuddanian	15.5				
ORDOVICIAN	U	Hirnantian	1.9	Lower Auen Dolomite	Schattloch Phyllites		
		Katian	10.2				
	Sandbian	5.1	Golzeck Porphyry				
	M	Darriwilian		Golzeck Formation			

Text-Fig. 3.  
Literature-based subdivision and correlation of the Auen, Pranker, Murau and Althofen groups (Gurktal Nappe).

**Derivation of name:** After a magmatic unit at Mount Golzeck (in the Auen area).

**Synonyms:** Golzeck-Quarzporphyr (NEUBAUER, 1979).

**Lithology:** Quarzporphyry and purple metatuffs.

**Fossils:** -

**Origin, facies:** Following NEUBAUER (1984: p. 56) the Golzeck Porphyry forms the volcanic basement of a submarine swell facies which is represented by the overlying carbonatic development of the Auen Group; magmatic unit.

**Chronostratigraphic age:** Late Ordovician age is concluded by GOSEN et al. (1985: p. 696), as this unit is overlain by meta-rhyolites and carbonates (Lower Auen Dolomite), of which the base of the latter deposits is assigned to the *ordovicicus* Zone (NEUBAUER, 1979: p. 464).

**Biostratigraphy:** -

**Thickness:** Approx. 7 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks at Golzeck Formation).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Golzeck Formation (conformable contact).

**Overlying unit(s):** Lower Auen Dolomite (conformable contact).

**Lateral unit(s):** Schattloch Phyllites.

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984).

### Unterer Auen-Dolomit / Lower Auen Dolomite

THOMAS J. SUTTNER

**Validity:** Invalid; the name "Unterer Auen-Dolomit" for this unit was first used by NEUBAUER (1979: p. 464), who mapped and revised the Lower Paleozoic succession of low metamorphic sediments around Murau.

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Section approx. 100 m north of Haider farmstead located south of Murau in the Auen area (N 47°02'33" / E 14°09'16").

**Derivation of name:** After Auen area (compare locality map of NEUBAUER, 1979: Fig. 1).

**Synonyms:** Dolomitkeile von Laßnitzau [partim] (TURNER, 1956: p. 164).

**Lithology:** Micaceous light pink to greenish marbles, ferruginous dolomite lense, bright and grey dolomite (massive and bedded intervals).

**Fossils:** Conodonts.

**Origin, facies:** Shallow marine, neritic unit.

**Chronostratigraphic age:** Katian to Hirnantian (NEUBAUER, 1979).

**Biostratigraphy:** *ordovicicus* conodont zone.

**Thickness:** 6 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks at Golzeck Formation).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Golzeck Porphyry (conformable contact).

**Overlying unit(s):** Middle Auen Dolomite (unconformable contact).

**Lateral unit(s):** Schattloch Phyllites (conformable contact).

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** -

**Complementary references:** THURNER (1958), EBNER et al. (1977), NEUBAUER (1979, 1984), NEUBAUER & PISTOTNIK (1984), SCHÖNLAUB (1992).

### Mittlerer Auen-Dolomit / Middle Auen Dolomite

THOMAS J. SUTTNER

**Validity:** Invalid; the name Mittlerer Auen-Dolomit for this unit was first used by NEUBAUER (1979: p. 464), who mapped and revised the Lower Paleozoic succession of low metamorphic sediments around Murau.

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Section in the vicinity of Haider farmstead located south of Murau in the Auen area (N 47°02'36" / E 14°09'18").

**Derivation of name:** After Auen area (compare locality map of NEUBAUER, 1979: Fig. 1).

**Synonyms:** Dolomitkeile von Laßnitzau [partim] (THURNER, 1956: p. 164).

**Lithology:** Dark, massive ferruginous dolomite (lower part of the unit); grey dolomites with crinoid stem plates which are overlain by tuffs and metapsammities (upper part of the unit).

**Fossils:** Conodonts, crinoids.

**Origin, facies:** Shallow marine, neritic unit.

**Chronostratigraphic age:** Homeric to ?Lochkovian (see remarks).

**Biostratigraphy:** Following NEUBAUER (1979: Tab. 1, p. 465–466) conodonts referring to the *sagitta*, *ploeckensis*, *siluricus* and *crispa* zones are identified.

**Thickness:** 20 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks at Golzeck Formation).

**Lithostratigraphic subdivision:** According to lithology a lower and upper part was discriminated by NEUBAUER (1979).

**Underlying unit(s):** Lower Auen Dolomite (unconformable contact).

**Overlying unit(s):** Haider Marble (Adelsberg Limestone) (conformable contact).

**Lateral unit(s):** ?Schattloch Phyllites; Pranker Metaclastics.

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** The age confinement is based on conodont biostratigraphy. The microfossil material was extracted from five samples of sections 2 and 3 near Haider farmstead (NEUBAUER, 1979: Figs. 2, 3). Hence some of these samples yield temporally long ranging conodont taxa, an Early Devonian age for the upper part of the unit cannot be excluded (NEUBAUER, 1979: p. 465–466).

**Complementary references:** THURNER (1958), NEUBAUER (1984), NEUBAUER & PISTOTNIK (1984), SCHÖNLAUB (1992).

### Haider-Marmor (Adelsbergkalk) / Haider Marble (Adelsberg Limestone)

THOMAS J. SUTTNER

**Validity:** Invalid; the name Haider-Marmor for this unit was first used by NEUBAUER (1979: p. 466), who mapped and revised the Lower Paleozoic succession of low metamorphic sediments around Murau.

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau, 4226 Judenburg (ÖK50-BMN, map sheets 158 Stadl, 159 Murau, 160 Neumarkt in der Steiermark).

**Type section:** Dolomitkeile von Laßnitzau [partim] (THURNER, 1956: p. 164).

**Reference section(s):** Section along the forest road approx. 250 m SE of Haider farmstead (compare NEUBAUER, 1979: p. 467) which is located south of Murau in the Auen area (N 47°02'21" / E 14°09'25").

**Derivation of name:** After the Haider farmstead (Auen area).

**Synonyms:** Karbonatkomplex des Adelsberges (NEUBAUER, 1980a).

**Lithology:** Micaceous yellowish marble (beds 0.5 to 1 m thick), flaser limestone, light grey dolomite, bright grey laminated limestone.

**Fossils:** Conodonts, crinoids.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Lochkovian to Emsian.

**Biostratigraphy:** Few broken polygnathid conodonts from the upper part of the unit suggest that this unit might have been deposited during the early Middle Devonian (compare NEUBAUER, 1979: p. 467).

**Thickness:** 20 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks at Golzeck Formation).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Middle Auen Dolomite (conformable contact).

**Overlying unit(s):** Upper Auen Dolomite (unconformable contact).

**Lateral unit(s):** Pranker Metaclastics; Ursch Dolomite (Kaindorf Dolomite).

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** -

**Complementary references:** THURNER (1958), NEUBAUER (1984), NEUBAUER & PISTOTNIK (1984), SCHÖNLAUB (1992).



## Schattloch-Phyllite / Schattloch Phyllites

THOMAS J. SUTTNER

**Validity:** Invalid; first mapped by GEYER (1891a, b); well described by NEUBAUER (1979).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Outcrops are located in the area near Lorenzengraben (compare NEUBAUER, 1979: Fig. 5, p. 468) at Mount Schattloch (N 47°02'00" / E 14°03'25"), southern slope of Schwarmbrunnhöhe (N 47°01'13" / E 14°04'47") to south-east of Ursch (N 47°01'50" / E 14°05'41").

**Derivation of name:** After Mount Schattloch (2,033 m).

**Synonyms:** Graue bis grauschwarze Phyllite (THURNER, 1961).

**Lithology:** Carbonaceous phyllites, chlorite-bearing phyllites, grey phyllites with quartz pebbles, metaporphyrites with phyllitic emplacements, limonitic limestone lenses (one lense with a thickness of about 1.5 m was observed by NEUBAUER (1979) along the section north of the "Hauserhütte" 1,720 meters above sea-level), metatuffs, at the base of the metatuff bright laminated limestone (1 m in thickness).

**Fossils:** -

**Origin, facies:** Marine deposits consisting of weathered products of acidic volcanites and metamorphic rocks (compare NEUBAUER, 1984: Fig. 17: "Phyllit of Frauenalpe", p. 56); phyllitic unit.

**Chronostratigraphic age:** ?Darrwilian–Ludlow.

**Biostratigraphy:** -

**Thickness:** > 250 m (NEUBAUER, 1979).

**Lithostratigraphically higher rank unit:** Pranker Group (see remarks).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Magdalensberg Group; Kaser Group; "Metadiabase".

**Overlying unit(s):** Pranker Metaclastics (conformable contact).

**Lateral unit(s):** Golzeck Formation; Golzeck Porphyry; Lower Auen Dolomite; ?Middle Auen Dolomite; Nock Group; Rosental Formation; Eisenhut Group.

**Geographic distribution:** Styria and Carinthia, south of St. Lorenzen near Murau, close to the Styrian/Carinthian states border (NEUBAUER, 1979: Figs. 1, 5).

**Remarks:** NEUBAUER (1979) distinguished three groups within the lower Paleozoic sequence of the Gurktal Nappe: the Auen Group, Pranker Group and Murau Group. The Pranker Group (compare Text-Fig. 3) is dominated mainly by low grade metamorphosed clastic units (Schattloch Phyllites and Pranker Metaclastics) and carbonate deposits (Ursch Dolomite). An equivalent development to the Schattloch Phyllites might be the "Phyllit-Grünschiefer-Folge" of Treibach-Althofen (GOSEN, 1978).

**Complementary references:** THURNER (1960), NEUBAUER & PISTOTNIK (1984), SCHÖNLAUB (1992).

## Pranker Metaklastika / Pranker Metaclastics

THOMAS J. SUTTNER

**Validity:** Invalid; first mapped by GEYER (1891a, b); well described by NEUBAUER (1979).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Area near Lorenzengraben (compare NEUBAUER, 1979: Fig. 4, p. 468) extending from south-eastern slopes of the Schattloch, Meterhöhe to Prankerhöhe (N 47°01'24" / E 14°04'05") via Schwarmbrunnhöhe (N 47°01'18" / E 14°04'47") to south-east of Ursch (N 47°01'46" / E 14°06'04").

**Derivation of name:** After Mount Prankerhöhe (2,166 m).

**Synonyms:** Arkosen mit Tonschieferlagen (THURNER, 1958); Arkosenschieferlagen (THURNER, 1961).

**Lithology:** Bright metapsammites, coarse grained metapsammites, grey and dark well bedded dolomite, carbonaceous phyllites, graphitic phyllites, grey phyllites.

**Fossils:** Conodonts.

**Origin, facies:** Near-shore to terrestrial unit.

**Chronostratigraphic age:** Ludfordian–Emsian.

**Biostratigraphy:** *crispa*, *eosteinhornensis* and *delta* conodont zones (NEUBAUER, 1979: Tab. 4, p. 475–477).

**Thickness:** > 550 m (NEUBAUER, 1979).

**Lithostratigraphically higher rank unit:** Pranker Group (see remarks at Schattloch Phyllites).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Schattloch Phyllites; Lower Auen Dolomite (unconformable contact).

**Overlying unit(s):** Ursch Dolomite (Kaindorf Dolomite) (conformable contact); Mölbling Dolomite (conformable contact); Mölbling Limestone (conformable contact).

**Lateral unit(s):** Middle Auen Dolomite; Haider Marble (Adelsberg Limestone); Eisenhut Group; Mölbling Dolomite; Mölbling Limestone; Lower Althofen Limestone.

**Geographic distribution:** Styria and Carinthia, south of St. Lorenzen near Murau, close to the Styrian/Carinthian states border (NEUBAUER, 1979: Figs. 1, 5).

**Remarks:** -

**Complementary references:** BECK-MANNAGETTA (1959), THURNER (1960), NEUBAUER (1984), NEUBAUER & PISTOTNIK (1984), GOSEN et al. (1985), SCHÖNLAUB (1992).

## Mölbling Dolomit / Mölbling Dolomite

BERNHARD HUBMANN

**Validity:** Invalid; description by BUCHROITHNER (1979: here-in lithological description of the "Paläozoikums-Aufbruch von Mölbling").

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** No type section defined; CLAR et al. (1963) published a profile of the "Althofen-Mölbling" quarries. BUCHROITHNER (1979) described the section at the Epritz quarry (N 46°51'33" / E 14°27'03").

**Reference section(s):** -

**Derivation of name:** After Mölbling, a municipality 27 km northeast of Klagenfurt.

**Synonyms:** ?untere Dolomitstufe (REDLICH, 1905).

**Lithology:** Ferruginous dolomites.

**Fossils:** Conodonts, ostracods, tentaculites.

**Origin, facies:** Shallow marine environment.

**Chronostratigraphic age:** Pridoli.

**Biostratigraphy:** *eosteinhornensis* zone.

**Thickness:** About 10 m.

**Lithostratigraphically higher rank unit:** Althofen Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** ?Mölbling Limestone.

**Overlying unit(s):** Lower Althofen Limestone.

**Lateral unit(s):** ?Mölbling Limestone.

**Geographic distribution:** Mölbling area; ÖK50-UTM, map sheet 4102 Althofen, ÖK50-BMN, map sheet 186 Sankt Veit an der Glan.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HEINISCH (1993).

### Mölbling Kalk / Mölbling Limestone

BERNHARD HUBMANN

**Validity:** Invalid; description by BUCHROITHNER (1979: here in lithological description of the “Paläozoikums-Aufbruch von Mölbling”).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** No type section defined; CLAR et al. (1963) published a profile of the “Althofen-Mölbling” quarries. BUCHROITHNER (1979) described the section at the Epritz quarry (N 46°51'33" / E 14°27'03").

**Reference section(s):** -

**Derivation of name:** After Mölbling, a municipality 27 km northeast of Klagenfurt.

**Synonyms:** Dunkler, grobbankiger Kalk (CLAR et al., 1963); partly: untere Dolomitstufe (REDLICH, 1905), Althofener Paläozoicum (HABERFELNER, 1936), Althofener Fazies (BUCHROITHNER, 1979).

**Lithology:** Dark colored well-bedded limestones, platy limestones.

**Fossils:** Conodonts, ostracods, tentaculites.

**Origin, facies:** Shallow marine environment.

**Chronostratigraphic age:** Pridoli–?(upper) Emsian.

**Biostratigraphy:** *eosteinhornensis*, *gronbergi* to upper *laticostatus* conodont zones.

**Thickness:** About 10 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** ?Pranker Metaclastics.

**Overlying unit(s):** Mölbling Dolomite.

**Lateral unit(s):** ?Pranker Metaclastics.

**Geographic distribution:** Mölbling area; ÖK50-UTM, map sheet 4102 Althofen, ÖK50-BMN, map sheet 186 Sankt Veit an der Glan.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HEINISCH (1993).

### Ursch-Dolomit (Kaindorf Dolomit) / Ursch Dolomite (Kaindorf Dolomite)

THOMAS J. SUTTNER

**Validity:** Invalid; Kaindorf Dolomite was first observed by THURNER (1935); described in detail by NEUBAUER (1979).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Area near Lorenzengraben, exposures are found near Ursch (compare NEUBAUER, 1979: p. 477; Mount Ursch: N 47°01'51" / E 14°06'03"); Kaindorf Dolomites are exposed south of St. Lorenzen near Murau in the vicinity of Schafflinger farmstead (compare NEUBAUER, 1979: Fig. 8, p. 481–482) (Schafflinger farmstead is located at N 47°05'59" / E 14°07'04").

**Derivation of name:** After Mount Ursch (1,848 m).

**Synonyms:** Dolomite von Kaindorf (THURNER, 1935).

**Lithology:** Bright yellowish weathering grey laminated dolomites (beds 40–60 cm thick), carbonaceous phyllites, micaceous marble.

**Fossils:** Conodonts, stromatoporoids or stromatolites? (NEUBAUER, 1979).

**Origin, facies:** Shallow marine, neritic unit.

**Chronostratigraphic age:** Emsian–Eifelian (NEUBAUER, 1979: p. 477); not only Emsian as mentioned in the ASC 2004.

**Biostratigraphy:** *kitabicus*, *gronbergi* and *kockelianus* conodont zones (NEUBAUER, 1979: Tab. 5, p. 477).

**Thickness:** > 20 m.

**Lithostratigraphically higher rank unit:** Pranker Group (see remarks at Schattloch Phyllites).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Pranker Metaclastics (conformable contact); Lower Althofen Limestone (conformable contact).

**Overlying unit(s):** -

**Lateral unit(s):** Haider Marble (Adelsberg Limestone); Lower Althofen Limestone.

**Geographic distribution:** Styria and Carinthia, south of Kaindorf near Murau, close to the Styrian/Carinthian states border (NEUBAUER, 1979: Figs. 1, 5, 8).

**Remarks:** The Kaindorf Dolomite is combined with the Ursch Dolomite since NEUBAUER (1984: Fig. 17, p. 56) as it shows a similar lithology and stratigraphic range. It differs in the sedimentary development that is exposed below the dolomites, as in the Ursch area metapsammities are exposed whereas in the Kaindorf area shales and purple to greenish platy flaser-dolomites are outcropping (compare NEUBAUER, 1979: Figs. 6, 9, p. 477, 481).

**Complementary references:** THURNER (1931, 1932, 1960), NEUBAUER (1984), NEUBAUER & PISTOTNIK (1984), GOSEN et al. (1985), SCHÖNLAUB (1992).

## Unterer Althofenkalk / Lower Althofen Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; first observations within the limestone deposits near Althofen were made by REDLICH (1905) and later described in more detail by HABERFELNER (1936). A description including all criteria necessary for a formal lithostratigraphic characterization is provided by SCHÖNLAUB (1971c: Figs. 1, 2, p. 291).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** Ancient quarry of Aich (SCHÖNLAUB, 1971c: Figs. 1, 2, p. 289) some hundred meters NNW of the town Treibach-Althofen (N 46°52'46" / E 14°28'03").

**Reference section(s):** -

**Derivation of name:** After the town Althofen, Carinthia.

**Synonyms:** -

**Lithology:** Platy limestone with chert, dark flaser and laminated limestone with black marly layers and crinoidal debris layers interbedded, light grey dolomite, thin bedded limestones.

**Fossils:** Conodonts, crinoids, ostracods?, radiolarians, tentaculites.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Emsian–Eifelian.

**Biostratigraphy:** The conodont assemblage hints to an Emsian age, but definite zones are not mentioned (SCHÖNLAUB, 1971c).

**Thickness:** Approx. 40 m.

**Lithostratigraphically higher rank unit:** Althofen Group (see Text-Fig. 3 and remarks).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Mölbling Dolomite (conformable contact); Mölbling Limestone (conformable contact).

**Overlying unit(s):** Reef-debris limestone of Althofen (conformable contact).

**Lateral unit(s):** Prank Metaclastics; Ursch Dolomite (Kaindorf Dolomite); Eisenhut Group.

**Geographic distribution:** Carinthia, in the area between Althofen and Töscheldorf.

**Remarks:** The Althofen Group (compare Text-Fig. 3) was introduced by SCHÖNLAUB (1971c). This group is subdivided into four distinctive units, consisting of the Lower Althofen Limestone, Reef-debris limestone of Althofen, Althofen Limestone Breccia and the Upper Althofen Formation.

**Complementary references:** SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984), KREUTZER et al. (1997).

## Riffschuttkalke von Althofen / Reef-debris limestones of Althofen

THOMAS J. SUTTNER

**Validity:** Invalid; first observations within the limestone deposits near Althofen were made by REDLICH (1905) and later described more in detail by HABERFELNER (1936). A description including all criteria necessary for a formal lithostratigraphic characterization is provided by SCHÖNLAUB (1971c: Figs. 1, 2, p. 297).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** Ancient quarry of Aich (SCHÖNLAUB, 1971c: Figs. 1, 2, p. 289) some hundred meters NNW of Treibach-Althofen (N 46°52'46" / E 14°28'03").

**Reference section(s):** -

**Derivation of name:** After the town Althofen.

**Synonyms:** Graue Riffkalke (HABERFELNER, 1936); Althofen Biogenschuttkalke (SCHÖNLAUB, 1971c).

**Lithology:** Grey massive limestone, rich in macrofossils.

**Fossils:** Calcareous green algae, conodonts, crinoids, red algae, rugose and tabulate corals, stromatoporoids.

**Origin, facies:** Shallow marine limestone, neritic unit.

**Chronostratigraphic age:** Eifelian.

**Biostratigraphy:** Conodonts constricting the age of the unit to late Eifelian (SCHÖNLAUB, 1971c), but a distinct zone is not mentioned.

**Thickness:** Approx. 3 m.

**Lithostratigraphically higher rank unit:** Althofen Group (see remarks at Lower Althofen Limestone).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Althofen Limestone (conformable contact).

**Overlying unit(s):** Althofen Limestone Breccia (unconformable contact).

**Lateral unit(s):** -

**Geographic distribution:** Carinthia, in the area between Althofen and Töscheldorf.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984), FENNINGER & HUBMANN (1994), KREUTZER et al. (1997).

## Nock-Gruppe / Nock Group

BERNHARD HUBMANN

**Validity:** Invalid; name and position of the unit published within a lithostratigraphic frame in SCHÖNLAUB & HEINISCH (1993: "Nock Group").

**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein).

**Type section:** No type section defined; type region at the Nockalmstraße (Nockalmhof: N 46°57'15" / E 13°43'37").

**Reference section(s):** -

**Derivation of name:** After the "Nockberge", mountains of rounded shape.

**Synonyms:** Nock-Serie (LOESCHKE, 1989b); partly: Nockgruppe (HOLDHAUS, 1933), vulkanogene Basisfolgen (NEUBAUER & PISTOTNIK, 1984).

**Lithology:** Greenschists and phyllites; in the upper part limestones occur.

**Fossils:** Conodonts (from limestones in the upper part of the succession).

**Origin, facies:** Probably shallow marine environment.

**Chronostratigraphic age:** ?Middle–Upper Ordovician.

**Biostratigraphy:** -

**Thickness:** Some hundreds of meters?

**Lithostratigraphically higher rank unit:** -  
**Lithostratigraphic subdivision:** -  
**Underlying unit(s):** Different units of the Kaser Group.  
**Overlying unit(s):** Rosental Formation.  
**Lateral unit(s):** -  
**Geographic distribution:** In the area of the Nockalm road; ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein).  
**Remarks:** -  
**Complementary references:** NEUBAUER & PISTOTNIK (1984), LOESCHKE (1989b), SCHÖNLAUB & HEINISCH (1993).

### Rosental-Formation / Rosental Formation

BERNHARD HUBMANN

**Validity:** Invalid; name of the formation and position of the unit published within a lithostratigraphic frame in SCHÖNLAUB & HEINISCH (1993: "Rosental Fm.").  
**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein).  
**Type section:** No type section published; type region Rosental (N 46°54'25" / E 13°48'48"), a valley in the Nockalm area. NEUBAUER & PISTOTNIK (1984) published a section (location point 1 in Fig. 1 and section 1 "Nockstrasse" in Fig. 2).  
**Reference section(s):** -  
**Derivation of name:** After Rosental in Carinthia, a valley north of Bad Kleinkirchheim.  
**Synonyms:** Partly: "Vulkanogene Basisfolgen" of NEUBAUER & PISTOTNIK (1984).  
**Lithology:** Phyllites with various ferruginous dolomites and cherty intercalations that are overlain by tuffites and greenschists.  
**Fossils:** Conodonts.  
**Origin, facies:** Probably shallow marine environment.  
**Chronostratigraphic age:** Upper Ordovician.  
**Biostratigraphy:** -  
**Thickness:** ?  
**Lithostratigraphically higher rank unit:** -  
**Lithostratigraphic subdivision:** -  
**Underlying unit(s):** Units of the Nock Group.  
**Overlying unit(s):** ?Eisenhut Group.  
**Lateral unit(s):** -  
**Geographic distribution:** Along the Nockalm road in the area of the Rosentaler Alm up to an altitude of 1,800 m; ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein).  
**Remarks:** -  
**Complementary references:** -

### Eisenhut-Gruppe / Eisenhut Group

BERNHARD HUBMANN

**Validity:** Invalid; first nomination by PETERS (1855: "Eisenhut-Schieferserie"), comprehensive description by KERNER & LOESCHKE (1991: "Eisenhutschiefer").

**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 184 Ebene Reichenau).

**Type section:** No type section defined; typical rocks are exposed at Eisenhut mountain (N 46°57'08" / E 13°55'42") (see sections in KERNER (1990) and KERNER & LOESCHKE (1991)).

**Reference section(s):** -

**Derivation of name:** After Eisenhut (2,441 m), a mountain near Turracher Höhe, approximately 65 km northwest of Klagenfurt.

**Synonyms:** Eisenhut-Schieferserie (PETERS, 1855); Eisenhutschiefer (SCHWINNER, 1932, 1938); Eisenhut-Schiefer (IIIb) (SCHWINNER, 1936); Eisenhutschiefer (HERITSCH, 1943; SCHÖNLAUB, 1979; KERNER & LOESCHKE, 1991); Eisenhutschiefer der Turracher Höhe (SCHÖNLAUB, 1979); "Eisenhutschiefer partim" (FLÜGEL & NEUBAUER, 1984); Eisenhutschieferserie (MULFINGER, 1988); volcanoclastic Eisenhut Group (SCHÖNLAUB & HEINISCH, 1993).

**Lithology:** Weakly metamorphosed lila-colored ash tuffs, dark-green hyaloclastites and green tuffites, dolomite lenses.

**Fossils:** Conodonts within the dolomite lenses.

**Origin, facies:** According to KERNER & LOESCHKE (1991) the formation of most of the rocks of the Eisenhut Group is the result of intra-plate volcanic activity which occurred in a tensional tectonic regime on thinned continental crust during the Silurian. Phreatomagmatic processes were responsible for the formation of the tuffs and hyaloclastites.

**Chronostratigraphic age:** Lower Silurian–(presumably) Lower Devonian.

**Biostratigraphy:** -

**Thickness:** About 200 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Rosental Formation.

**Overlying unit(s):** ?

**Lateral unit(s):** Murau Group (?).

**Geographic distribution:** Gurktal mountains; ÖK50-BMN, map sheet 184 Ebene Reichenau.

**Remarks:** -

**Complementary references:** -

### „Klastische Gruppe“ / "Clastic Group"

BERNHARD HUBMANN

**Validity:** Invalid; comprehensive description of the unit by MULFINGER (1988: "Klastische Serie").

**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 184 Ebene Reichenau).

**Type section:** No type section defined; MULFINGER (1988) mentioned typical occurrences at Rapitzsattel (2,088 m; N 46°55'56" / E 13°56'35"), Torer and Spielriegel to Schafferalm (1,365 m; N 46°58'10" / E 14°00'14").

**Reference section(s):** -

**Derivation of name:** Collective name for a unit built up by various clastic rocks.

**Synonyms:** Klastische Serie (MULFINGER, 1988).

**Lithology:** At the base coarse grained massive sandstones frequently alternating with argillaceous shales and phyllites. Sandstones are mostly developed as light colored arkoses, feldspar-rich fine-grained grey sandstones and light-colored quartz-sandstones.

**Fossils:** -

**Origin, facies:** Probably sediments of a marginal marine basin.

**Chronostratigraphic age:** ?Middle–Upper Ordovician.

**Biostratigraphy:** -

**Thickness:** Strong variations; up to 1,000 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Magdalensberg Group, Kaser Group.

**Overlying unit(s):** Murau Group, ?Eisenhut Group.

**Lateral unit(s):** ?Nock Group.

**Geographic distribution:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheets 183 Radenthein, 184 Ebene Reichenau).

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HEINISCH (1993).

### Murau-Gruppe / Murau Group

THOMAS J. SUTTNER

**Validity:** Invalid; the name Murau-Gruppe was introduced by NEUBAUER (1979: p. 484).

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Area between Bodendorfer Ochsenberg and Rosenkranzhube south of St. Lorenzen; the best outcropping section is found close to the Lorenz creek north of Konrad farmstead in the area of Georgenberg (N 47°05'38" / E 14°05'31"); Birkleitenkogel (NEUBAUER, 1979: Fig. 10, p. 484).

**Derivation of name:** After the town Murau.

**Synonyms:** Phyllitische Glimmerschiefer (THURNER, 1935); Phyllonite [partim] (THURNER, 1935).

**Lithology:** Fine grained micaceous shale, graphitic micaceous shale containing sometimes garnet, phyllites, siliceous shale, phyllites with carbonate lenses, quartzite beds, siliceous shale with lydites intercalated, grey bedded dolomite, grey laminated micaceous shale.

**Fossils:** Conodonts.

**Origin, facies:** The depositional environment suggests an euxinic basin with intercalations of calciturbidites (NEUBAUER, 1984: p. 57).

**Chronostratigraphic age:** Llandovery–Ludlow.

**Biostratigraphy:** *sagitta* and *crispa* conodont zones.

**Thickness:** > 200 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** "Clastic Group" (conformable contact).

**Overlying unit(s):** Murau Limestone (Greibenzen Limestone) (conformable contact).

**Lateral unit(s):** Eisenhut Group; "Gurktal Quartzphyllite Complex".

**Geographic distribution:** Styria, surrounding of Murau between Bodendorfer Ochsenberg and Lorenzer Bach (NEUBAUER, 1979: Figs. 1, 10, p. 484).

**Remarks:** NEUBAUER (1979) distinguished 3 groups within the Lower Paleozoic sequence of the Gurktal Nappe: the Auen Group, Pranker Group and Murau Group. The Murau Group consists of several epimetamorphic units which are not discriminated into distinctive formations until now (compare Text-Fig. 3).

**Complementary references:** THURNER (1958), SCHÖNLAUB (1979, 1992).

### Murau-Kalk (Greibenzenkalk) / Murau Limestone (Greibenzen Limestone)

BERNHARD HUBMANN

**Validity:** Invalid; early descriptions by ROLLE (1854: "Kalklager der Grebenzen") and GEYER (1891a: "Kalke [der Murauer Mulde]"); THURNER (1933) considered the Grebenzenkalk as a facial variety of the "Murauer Kalk".

**Type area:** ÖK50-UTM, map sheet 4225 Murau (ÖK50-BMN, map sheet 159 Murau).

**Type section:** No type section defined; THURNER (1933) mentioned typical "Murauer Kalke" at Blasenkogel (1,602 m; N 47°06'44" / E 14°18'26"); METZ (1963) specified the Grebenzen (1,870 m; N 47°02'21" / E 14°19'49"), a mountain north of Friesach (Carinthia) as "locus typicus" for the Grebenzen Limestone.

**Reference section(s):** -

**Remarks:** The synonymy of Murau Limestone and Grebenzen Limestone respectively their relationship is a matter of controversy in the literature.

**Derivation of name:** After the town Murau respectively the mountain Grebenzen (1,900 m).

**Synonyms:** Grebenzenkalk (THURNER, 1930); Murauer Kalke (THURNER, 1930); Murauer-Kalke und Dolomite (THURNER, 1952); Grebenzer-Kalk (THURNER, 1952); Pleschaitz-Kalk (THURNER, 1952); Grebenzen-Pleschaitz-kalk (SCHÖNLAUB, 1979); Bänderkalke (Typ Murau) (SCHÖNLAUB, 1979); Murau-Kalk (NEUBAUER, 1980b); Kalke der Grebenzen und des Pleschaitz (THURNER & VAN HUSEN, 1980); Murauer Kalke (THURNER & VAN HUSEN, 1980); Murauer Bänderkalke (THURNER & VAN HUSEN, 1980); Murauer Kalk (FLÜGEL & NEUBAUER, 1984); Grebenzenkalk (FLÜGEL & NEUBAUER, 1984).

**Lithology:** Recrystallized banded limestones and marbles. Locally lower parts of the succession are dominated by grey laminated marbles which contain fragments of crinoids whereas upper parts are mainly built up by whitish to pink colored marbles which are in some part cloudy dolomitized.

**Fossils:** Crinoids and rare conodonts.

**Origin, facies:** Open marine environment (?).

**Chronostratigraphic age:** Pridoli–Emsian.

**Biostratigraphy:** -

**Thickness:** 200–800 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Murau Group.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Surroundings of Murau; ÖK50-BMN, map sheets 159 Murau, 160 Neumarkt.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HEINISCH (1993).

### Oberer Auen-Dolomit / Upper Auen Dolomite

THOMAS J. SUTTNER

**Validity:** Invalid; the name Oberer Auen-Dolomit for this unit was first used by NEUBAUER (1979: p. 467), who mapped and revised the low metamorphic Lower Paleozoic succession in the surroundings of Murau.

**Type area:** ÖK50-UTM, map sheets 3230 Tamsweg, 4225 Murau (ÖK50-BMN, map sheets 158 Stadl, 159 Murau).

**Type section:** -

**Reference section(s):** Section in the vicinity of Haider farmstead located south of Murau in the Auen area (N 47°02'26" / E 14°09'19").

**Derivation of name:** After Auen area (compare locality map of NEUBAUER, 1979: Fig. 1).

**Synonyms:** Dolomitkeile von Laßnitzau [partim] (TURNER, 1956: p. 164).

**Lithology:** Bedded and massive grey limonitic dolomites; dark grey unbedded, brecciated dolomite.

**Fossils:** Conodonts.

**Origin, facies:** Shallow marine limestone, neritic unit.

**Chronostratigraphic age:** Frasnian–Famennian.

**Biostratigraphy:** *asymmetricus* and *gigas* conodont zones.

**Thickness:** 10 m.

**Lithostratigraphically higher rank unit:** Auen Group (see remarks at Golzeck Formation).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Haider Marble (Adelsberg Limestone) (unconformable contact).

**Overlying unit(s):** Upper Althofen Formation; Shale, Lydite Breccia (unconformable contact).

**Lateral unit(s):** Althofen Limestone Breccia.

**Geographic distribution:** Styria and Carinthia, in the surrounding of Murau, especially south of it near the Styrian/Carinthian states border in the area of Auen (NEUBAUER, 1979: Fig. 1).

**Remarks:** -

**Complementary references:** TURNER (1958), NEUBAUER (1984), NEUBAUER & PISTOTNIK (1984), SCHÖNLAUB (1992).

### Althofener Kalkbreckzie / Althofen Limestone Breccia

THOMAS J. SUTTNER

**Validity:** Invalid; first observations within the limestone deposits near Althofen were made by REDLICH (1905) and

later described in more detail by HABERFELNER (1936). A description including all criteria necessary for a formal lithostratigraphic characterization is provided by SCHÖNLAUB (1971c: Figs. 1, 2, p. 299).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** Ancient quarry of Aich (SCHÖNLAUB, 1971c: Fig. 1, 2; p. 289) some hundred meters NNW of Treibach-Althofen (N 46°52'46" / E 14°28'03").

**Reference section(s):** -

**Derivation of name:** After the town Althofen.

**Synonyms:** Knotenkalk (SCHÖNLAUB, 1971c).

**Lithology:** Limestone breccia (consisting of reworked pebbles of the Lower Althofen Limestone and the Reef-debris limestone of Althofen).

**Fossils:** Calcispheres, conodonts, crinoids, ostracods?, radiolarians.

**Origin, facies:** Shallow marine limestone, neritic unit.

**Chronostratigraphic age:** Generally, the unit is assigned to the Famennian by SCHÖNLAUB (1971c); Lower and Middle Devonian is indicated by reworked conodonts from underlying units.

**Biostratigraphy:** *asymmetricus*, *gigas* and *triangularis* conodont zones.

**Thickness:** Approx. 6 m.

**Lithostratigraphically higher rank unit:** Althofen Group (see remarks at Lower Althofen Limestone).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Reef-debris limestone of Althofen (unconformable contact).

**Overlying unit(s):** Upper Althofen Formation (conformable contact).

**Lateral unit(s):** Upper Auen Dolomite.

**Geographic distribution:** Carinthia, in the area between Althofen and Töscheldorf.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984), KREUTZER et al. (1997).

### Obere Althofen-Formation / Upper Althofen Formation

THOMAS J. SUTTNER

**Validity:** Invalid; first observations within the limestone deposits near Althofen were made by REDLICH (1905) and later described more in detail by HABERFELNER (1936). A description including all criteria necessary for a formal lithostratigraphic characterization is provided by SCHÖNLAUB (1971c: Figs. 1, 2, p. 300).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** Ancient quarry of Aich (SCHÖNLAUB, 1971c: Fig. 1, 2; p. 289) some hundred meters NNW of Treibach-Althofen (N 46°52'46" / E 14°28'03").

**Reference section(s):** -

**Derivation of name:** After the town Althofen.

**Synonyms:** -

**Lithology:** Thin, platy grey to reddish limestone.

**Fossils:** Conodonts.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Famennian.

**Biostratigraphy:** Conodonts restrict the unit to Upper Famennian (SCHÖNLAUB, 1971c), but a distinct zone is not mentioned.

**Thickness:** Approx. 2 m.

**Lithostratigraphically higher rank unit:** Althofen Group (see remarks at Lower Althofen Limestone).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Upper Auen Dolomite (conformable contact), Althofen Limestone Breccia (conformable contact).

**Overlying unit(s):** Shale, Lydite Breccia (unconformable contact).

**Lateral unit(s):** -

**Geographic distribution:** Carinthia, in the area between Althofen and Töscheldorf.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979, 1992), NEUBAUER & PISTOTNIK (1984), KREUTZER et al. (1997).

### Tonschiefer, Lyditbrekzien / Shale, Lydite Breccias

THOMAS J. SUTTNER

**Validity:** Invalid; first observations within the deposits near Althofen were made by REDLICH (1905) and later described more in detail by HABERFELNER (1936) and SCHÖNLAUB (1971c: Figs. 1, 2, p. 301).

**Type area:** ÖK50-UTM, map sheet 4102 Althofen (ÖK50-BMN, map sheet 186 Sankt Veit an der Glan).

**Type section:** Ancient quarry of Aich (SCHÖNLAUB, 1971c: Figs. 1, 2, p. 289) some hundred meters NNW of Treibach-Althofen (N 46°52'46" / E 14°28'03").

**Reference section(s):** -

**Derivation of name:** After lithological features.

**Synonyms:** Schiefer-Lyditbreccien-Komplex (SCHÖNLAUB, 1971c); Pelite-Chert-Formation (SCHÖNLAUB, 1992).

**Lithology:** Grey siliceous shale, lydites and lydite breccias.

**Fossils:** Radiolarians.

**Origin, facies:** Marine siliciclastics, pelagic unit.

**Chronostratigraphic age:** Tournaisian–Serpukhovian (see remarks).

**Biostratigraphy:** -

**Thickness:** Approx. 15 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Upper Althofen Formation (unconformable contact).

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Carinthia, in the area between Althofen and Töscheldorf.

**Remarks:** Due to the lack of stratigraphically relevant fossils, the age assignment follows the suggestions of CLAR et al. (1963) and SCHÖNLAUB (1971c: p. 301), who considered the Shale and Lydite Breccias being deposited above

the Upper Althofen Formation. Since the contact between these two units is unconformable, the Shale and Lydite breccias are probably restricted to lower Carboniferous deposits.

**Complementary references:** HABERFELNER (1936), SCHÖNLAUB (1979), NEUBAUER & PISTOTNIK (1984).

### „Gurktaler Quarzphyllit-Komplex“ / Gurktal Quartzphyllite Complex

BERNHARD HUBMANN

**Validity:** Invalid; description by BECK-MANNAGETTA (1959: "(Quarz-) Phyllitserie").

**Type area:** ÖK50-UTM, map sheet 4101 Gurk (ÖK50-BMN, map sheet 185 Straßburg).

**Type section:** No type section published; BECK-MANNAGETTA (1964) mentioned a typical occurrence of the Gurktal quartzphyllite at Weitensfeld (N 46°50'54" / E 14°11'30"), approximately 50 km north of Klagenfurt.

**Reference section(s):** -

**Derivation of name:** After the valley Gurktal, north of Feldkirchen in Carinthia.

**Synonyms:** Gurktaler Phyllit (SCHWINNER, 1932, 1936); (Quarz-) Phyllitserie (BECK-MANNAGETTA, 1959); Gurktaler Quarzphyllit (BECK-MANNAGETTA, 1964; KERNER, 1988; KERNER & LOESCHKE, 1991); Gurktaler Quarzphyllit-Komplex [sic!] (SCHÖNLAUB, 1979); Gurktal Quartzphyllite Complex (SCHÖNLAUB & HEINISCH, 1993); partly: Gurktaler Komplex (ZADORLAKY-STETTNER, 1961); Gurktaler und Mittelkärntner Quarzphyllitreal (SCHÖNLAUB, 1979); Altpaläozoischer Phyllit i.a. (FLÜGEL & NEUBAUER, 1984).

**Lithology:** Various epimetamorphic rocks; mostly dark-grey phyllites; in the upper parts dolomitic lenses up to 20 m in thickness may occur.

**Fossils:** Unknown.

**Origin, facies:** ?

**Chronostratigraphic age:** Presumably Ordovician–Carboniferous.

**Biostratigraphy:** -

**Thickness:** About 250 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** ?

**Overlying unit(s):** ?

**Lateral unit(s):** ?Murau Group.

**Geographic distribution:** Gurktal range; ÖK50-BMN, map sheets 184 Ebene Reichenau, 186 Stankt Veit an der Glan.

**Remarks:** -

**Complementary references:** NEUBAUER & SASSI (1993).

### Stangnock-Formation / Stangnock Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; the term was introduced and formalized by KRAINER (1989: p. 568) at the northwestern margin of the Gurktal Nappe System of Carinthia.

**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein) (PISTOTNIK, 1996), Carinthia. Area of Stangnock and mountain Königsstuhl

(2,336 m) in the Nock Mountains, in particular the area north of mountain Stangnock, approx. 2 km northeast of Karlbach and 6 km northwest of Turracher Höhe.

**Type section:** North of mountain Stangnock with exposures covering more than 300 m of the complete section; N 46°56'12" / E 13°47'50".

**Reference section(s):** -

**Derivation of name:** After the mountain Stangnock (2,316 m).

**Synonyms:** Anthrazitformation der Stangalpe; Oberkarbon der Stangalpe; Stangalm-Karbon; Königstuhl-Turracher-Karbon; Königstuhlkarbon; Turracher Karbon (cf. KRÄINER, 1989: p. 566).

**Lithology:** At the base coarse to fine-grained molasse-type sediments of a braided river network composed of quartz-rich polymict conglomerates, sandstones and arenaceous shales.

**Fossils:** Speciose flora (see FRITZ et al., 1990: p. 154–166).

**Origin, facies:** Intermontane molasse deposit containing abundant plant remains. The basal part grades upward into a gravel-sandstone facies of a meandering river system. In this sequence in the surroundings of Turracher Höhe meter-thick coal seams occur suggesting an overall humid climate.

**Chronostratigraphic age:** Kasimovian–Gzhelian (Stephanian), Pennsylvanian, upper Carboniferous.

**Biostratigraphy:** *Odontopteris cantabrica*–*Sphenophyllum angustifolium* Zone (Kasimovian–Gzhelian).

**Thickness:** > 400 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Paleozoic Series of the Stolzalpen Nappe (not shown in the ASC 2004).

**Overlying unit(s):** Werchzirm Formation.

**Lateral unit(s):** -

**Geographic distribution:** In the Gurktal Alps between Turracher Höhe and Flattnitz in the east and the area around the village of Innerkrems in the west.

**Remarks:** -

**Complementary references:** -

### „Oberkarbon von St. Paul“ / Upper Carboniferous of St. Paul

HANS P. SCHÖNLAUB

**Validity:** Invalid (THIEDIG & KLUSMANN, 1974: p. 81; THIEDIG et al., 1975: p. 271).

**Type area:** ÖK50-UTM, map sheet 4109 Sankt Paul im Lavanttal (ÖK50-BMN, map sheet 205 Sankt Paul im Lavanttal), Carinthia (KLEINSCHMIDT et al., 1989).

**Type section:** -

**Reference section(s):** -

Remarks: The Carboniferous sequence is exposed in two small outcrops southeast of St. Paul some 500 m east of the church of St. Josef and 200 m northwest of the farmhouse Pum.

**Derivation of name:** Named after the village of St. Paul east of Völkermarkt in the Lavant Valley.

**Synonyms:** -

**Lithology:** Soft greyish shales, greywackes and arkosic shales.

**Fossils:** Plants (*Sphenophyllum angustifolium*, *Aphlebia elongata*, *Pseudomariopteris busqueti* and others; FRITZ et al., 1990).

**Origin, facies:** Molasse-type sedimentation.

**Chronostratigraphic age:** Gzhelian (Stephanian)–Asselian.

**Biostratigraphy:** Based on plant fossils.

**Thickness:** Unknown.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Magdalensberg Group, Gurktal Quartzphyllite Complex (tectonic contact).

**Overlying unit(s):** Werchzirm Formation.

**Lateral unit(s):** -

**Geographic distribution:** Small isolated outcrops between St. Paul and the town of St. Veit in eastern Carinthia.

**Remarks:** -

**Complementary references:** -

### Werchzirm-Formation / Werchzirm Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by SCHWINNER (1931, 1932) at the northwestern margin of the Gurktal Nappe System of Styria.

**Type area:** ÖK50-UTM, map sheet 3106 Radenthein (ÖK50-BMN, map sheet 183 Radenthein): Werchzirbenalm (“Roter Rain”) some 3 km west of the village of Turrach, Styria.

**Type section:** Northeast directed crest along “Roter Rain” to “Werchzirmkessel”. The best outcrops are located between altitudes 2,000 m and 1,950 m (N 46°57'00" / E 13°49'23").

**Reference section(s):** Another section runs along the crest between the mountains Königstuhl and Karlnock west of Turracher Höhe overlying the Stangnock-Formation (SCHWINNER, 1938; KRÄINER, 1987b).

**Derivation of name:** After Werchzirmalm (today named “Werchzirbenalm”) west of the village of Turrach (Styria).

**Synonyms:** Werchzirmschichten, Freudenberger Schichten, Christofbergschichten, Postvariszische Transgressionsserien, Kontinentaldetritisches Perm (cf. KRÄINER, 1984: p. 169, 1987b: p. 52).

**Lithology:** Red siltstones, mudstones and sandstones with interbedded polymict conglomerates and fanglomerates (Red Beds).

**Fossils:** Plant remains.

**Origin, facies:** Debris flows alternating with playa-like sediments (caliche crusts, algal layers) and rhyolitic pyroclastics in the upper part (tuffs and tuffites) suggesting a semiarid and arid climate.

**Chronostratigraphic age:** Asselian.

**Biostratigraphy:** Based on plant occurrences at several localities at Christofberg, Ulrichsberg and the surround-



ings of St. Paul (Wunderstätten) an assignment to the *Calopteris conferta* Zone is inferred (FRITZ & KRAINER, 2007).

**Thickness:** Between 30 and 50 or even 100 meters (KRAINER, 1987b).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Stagnock Formation and Lower Paleozoic of Magdalensberg Group (tectonic contact).

**Overlying unit(s):** Gröden Formation.

**Lateral unit(s):** -

**Geographic distribution:** Gurktal Alps west of the village of Turrach (northwestern Styria) and central Carinthia between Ulrichsberg in the west and St. Paul in the east (KRAINER, 1987b).

**Remarks:** -

**Complementary references:** -

**Gröden-Formation / Gröden Formation**  
(description see Carnic Alps and Drau Range)

## Grazer Paläozoikum / Graz Paleozoic

The Graz Paleozoic (GP) comprises an outcropping area of approximately 1,250 km<sup>2</sup> resting tectonically on metamorphic Austroalpine units. The GP itself represents a pile of nappes which is overlain unconformably by the Upper Cretaceous Kainach Gosau and by Neogene sediments of the “Styrian Basin” in the south. The nappes consist of different facial developments.

FRITZ & NEUBAUER (1990) discerned a Basal, an Intermediate, and an Upper Nappe Group in which lithological similarities, the tectonic position, and metamorphic overprint of the nappes were considered. This concept of a tectonic tripartite arrangement in the sense of FRITZ & NEUBAUER (1990) is the conceptual base for the lithostratigraphic arrangement shown in the ASC 2004:

1) The Basal Nappe Group (upper Silurian–Lower Devonian) comprises the Schöckel Nappe and the Anger Crystalline Complex. Besides the Alpine (Early to Late Cretaceous) deformation of the Graz Paleozoic in this basal nappe system minor Variscan deformation under upper greenschist facies condition (with rarely occurring amphibolite facies) is detected. The Schöckel Nappe is made up of pre-Devonian rocks (Passail Group, Taschen Formation) and the Devonian Peggau Group. Generally, volcanics dominate the upper Silurian to Lower Devonian, and carbonates the Middle Devonian. Part of the Peggau Group is the Schönberg Formation with Meggen-type lead/zinc-barite Sedex mineralizations (EBNER et al., 2000).

2) The Intermediate Nappe Group (lower Silurian–Upper Devonian) includes the “Laufnitzdorf Nappe” and the “Kalkschiefer Nappe” (Lower to Upper Devonian). Both Nappes occur in different structural levels. The former development contains pelagic limestones, shales and volcanics, the latter limestones and siliciclastics.

3) The Upper Nappe System (upper Silurian–upper Carboniferous) comprises the Rannach- and Hochlantsch Nappes. Both have a similar facial development, especially in the Emsian–Givetian. Successions of the Rannach Nappe are composed of volcanoclastic rocks (Silurian–Lower Devonian; Reinerspitz Group), siliciclastics and carbonates rich in fossils (Lower–Middle Devonian; Rannach Group) of a littoral environment followed by the pelagic Forstkogel Group (Upper Givetian–Serpukhovian) and the shallow marine Dult Group (Bashkirian/?Moskavian) (HUBMANN & MESSNER, 2007; EBNER et al., 2008).

According to a paleogeographical interpretation of the entire Paleozoic succession, the formations of the Rannach- and Hochlantsch Nappes are interpreted to have been de-

posite nearest to the shore, while the “Laufnitzdorf Facies” represents the most distant from shore. Successions of the Schöckel Nappe occupy an intermediate position in this conception (HUBMANN, 1993).

The stratigraphic sequence indicates a sedimentation area changing from a passive continental margin with the continental breakup (alkaline volcanism) to shelf and platform geometries during the Silurian to Devonian time span. Sea-level changes and probably synsedimentary tectonics had affected both, the lithologic development (i.e., alternations of dolostones and limestones) and the formation of stratigraphic gaps and mixed conodont faunas (EBNER et al., 2000, 2008).

Recently, GASSER et al. (2010) published a new structural sketch of the Graz Paleozoic which gets along with only two nappes, a basal one characterized by intensely deformed units which show a penetrative foliation with a pronounced stretching lineation and an upper one comprising less metamorphic sequences. In this conception the lower nappe system consists of sequences of the Laufnitzdorf Facies, the Kalkschiefer Facies (partly) and the Schöckel Facies whereas the upper nappe system comprises the Kalkschiefer Facies (partly), the Rannach Facies and the Hochlantsch Facies.

## Taschen-Formation / Taschen Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by SCHWINNER (1925: “Taschenschiefer”); formalized by FLÜGEL (2000: p. 38; Taschen-Schiefer-Formation); change of name into Taschen-Formation by EBNER et al. (2000).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** Not defined, but FLÜGEL (2000) selected a type region at Taschen, a little village east of Peggau; ÖK50-UTM, map sheet 4223 Weiz, ÖK50-BMN, map sheet 164 Graz (N 47°12'27" / E 15°22'59").

**Reference section(s):** -

**Remarks:** Tectonic position of the formation and its relationship to the Rannach Nappe or Schöckel Nappe respectively is not clarified at the moment.

**Derivation of name:** After “Taschen”, an area east of Peggau, approx. 25 km north of Graz.

**Synonyms:** Partly: Semriacher Schiefer (CLAR, 1874); obere Schiefer (HERITSCH, 1917b); Grünschiefer-Serie (SEE-

WANN, 1929); Chloritschiefer des Bergler Kogel (FLÜGEL, 1957); Stanzberg Serie (GRÄF, 1958); erzführende Serie (WEBER, 1990); Arzberg Schichten (EBNER & WEBER, 1978); Waldstein-Formation (FRITZ, 1991).

**Lithology:** Alkaline volcanoclastics; sometimes intercalations of dark coloured shales.

**Fossils:** -

**Origin, facies:** -

**Chronostratigraphic age:** Presumably pre-Ludlow.

**Biostratigraphy:** -

**Thickness:** Several hundreds of meters.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Successions of the Passail Group.

**Overlying unit(s):** Semriach Formation, ?Schönberg Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 133 Leoben, 134 Passail, 162 Köflach, 163 Voitsberg, 164 Graz.

**Remarks:** -

**Complementary references:** -

### St. Jakob-Formation / St. Jakob Formation

BERNHARD HUBMANN

**Validity:** Valid; first description and nomination by THALHAMMER (1982: "St. Jakob-Gruppe"); formalized by FLÜGEL (2000: p. 11; "St. Jakob-Formation"); change of name into St. Jakob-Formation by EBNER et al. (2000).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** Not defined, but according to FLÜGEL (2000) the type region is in the vicinity of St. Jakob in Breitenau (N 47°23'05" / E 15°26'11").

**Reference section(s):** -

**Remarks:** THALHAMMER (1982) distinguished within the "St. Jakob-Group" three units which were adopted by FLÜGEL (2000) as members of the St. Jakob Formation (see below).

**Derivation of name:** After the village St. Jakob, 52 km north of Graz.

**Synonyms:** Carbonschichten der Breitenau (VACEK, 1891); partly: Karbon der Breitenau (FLÜGEL, 1953a); Magnesit der Breitenau (H. FLÜGEL, 1975).

**Lithology:** Limestones, siliciclastics and alkaline metavolcanites.

**Fossils:** Conodonts.

**Origin, facies:** Pelagic environment.

**Chronostratigraphic age:** Llandovery–Givetian; does not reach up into the Eifelian as indicated in the ASC 2004.

**Biostratigraphy:** *costatus* Zone and *varcus* Zone.

**Thickness:** Up to 280 m.

**Lithostratigraphically higher rank unit:** Laufnitzdorf Group.

**Lithostratigraphic subdivision:** FLÜGEL (2000) discerned three members:

Aibl Member: Limestones, sandstones, alkaline volcanoclastics; about 180 m in thickness.

Breitenau Member: Magnesites and dolomites; up to 100 m in thickness.

Schattleiten Member: Succession of limestones, argillaceous shales and silt/sandstones; 80–100 m in thickness.

**Underlying unit(s):** Tectonic contact to Kogler Formation.

**Overlying unit(s):** Tectonic contact to Kogler Formation.

**Lateral unit(s):** Unknown because of tectonic boundaries.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Remarks:** -

**Complementary references:** GOLLNER et al. (1982), FLÜGEL & NEUBAUER (1984).

### Semriach-Formation / Semriach Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by CLAR (1874: "Semriacher Schiefer"); formalized by FLÜGEL (2000: p. 47; Semriacher-Phyllit-Formation); change of name into Semriach-Formation by EBNER et al. (2001).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) selected a type region at Windhofkogel (1,064 m) east of Semriach (N 47°13'28" / E 15°26'09").

**Reference section(s):** -

**Remarks:** Tectonic position of the formation and its relationship to the Rannach Nappe or Schöckel Nappe respectively is not clarified at the moment.

**Derivation of name:** After Semriach, a small town northeast of Peggau-Deutschfeistritz, approx. 30 km north of Graz.

**Synonyms:** Semriacher Schiefer (CLAR, 1874); partly: Untere Schiefer (HERITSCH, 1906); Phyllite von Semriach and Phyllite von Passail (SCHWINNER, 1925); Serie der Phyllite (SEEWANN, 1929); Schiefer der Passailer Mulde (H. FLÜGEL, 1975).

**Lithology:** Sericite phyllites with insertions of green schists; marbles.

**Fossils:** -

**Origin, facies:** -

**Chronostratigraphic age:** Presumably pre-Devonian.

**Biostratigraphy:** -

**Thickness:** Presumably several hundreds of meters.

**Lithostratigraphically higher rank unit:** Passail Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** FLÜGEL (2000) discerned two members:

Hundsberg Member: Coarse grained quartzites and quartzitic slates; 10 to 50 m in thickness.

Rötschgraben Member: White to bluish-white fine-grained marbles; few meters in thickness.

**Underlying unit(s):** In its southern outcropping area the formation shows a tectonic contact to green schists of the Taschen Formation. North of Plenzengreith a marble ho-

rizon separates the Semriach Formation from the St. Radegund Crystalline. In the area of St. Kathrein the Hochschlag Formation underlies the Semriach Formation.

**Overlying unit(s):** Schönberg Formation and Schöckel Formation (tectonic contact).

**Lateral unit(s):** Not known because of tectonic boundaries.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 135 Birkfeld, 164 Graz, 165 Weiz.

**Remarks:** -

**Complementary references:** -

### Schönberg-Formation / Schönberg Formation

BERNHARD HUBMANN

**Validity:** Valid; re-nomination of "Arzberg Schichten" (see FLÜGEL, 2000: p. 39), formalized by FLÜGEL (2000: p. 39).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined, but FLÜGEL (2000) selected a type region at Schönberg, northeast of Arzberg; ÖK50-BMN, map sheet 164 Graz (N 47°15'53" / E 15°31'58").

**Reference section(s):** -

Remarks: Characteristic of the formation is the synsedimentary lead-zinc-silver-barite-mineralization.

**Derivation of name:** After "Schönberg", a municipality and hill northeast of Arzberg, approx. 35 km north of Graz.

**Synonyms:** Partly: Grenzphyllit (CLAR, 1874); untere Schiefer (HERITSCH, 1917c); Graphitphyllitserie (SEEWANN, 1929); Tonschiefer-Fazies (FLÜGEL & MAURIN, 1952); Karbon von Waldstein (FLÜGEL, 1953a); Striatoporen-Kalk (H. FLÜGEL, 1975); dunkle, pigmentreiche Gesteine ("Schwarzschiefer") (WEBER, 1977); höhere karbonat- und kohlenstoffreiche Serie (WEBER, 1977); tiefere, grüngesteinbe-tonte Serie (WEBER, 1977); Arzberg Schichten (EBNER & WEBER, 1978); erzführende Serie (WEBER, 1990).

**Lithology:** Predominantly black shales and darkgrey to black limestones with high amounts of clay.

**Fossils:** Very rare and badly preserved tabulate corals (mostly thamnoporids).

**Origin, facies:** Organic carbon-rich sediments of a euxinic basin.

**Chronostratigraphic age:** Presumably Lochkovian–Emsian/Eifelian.

**Biostratigraphy:** -

**Thickness:** Probably more than 300 m.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** FLÜGEL (2000) distinguished four facial types which were considered as members:

Kreuzwirt Member: Particularly dark coloured limestones and dolomites that may be intercalated with black shales; thickness up to 200 m.

Rabenstein Member: Dark grey crinoidal limestones; 30 to 50 m in thickness.

Rauchenberg Member: Carbonatic black shales; probably more than 300 m in thickness.

Weizbauer Member: Black argillaceous shales with intercalated beds of limestones and quartzites; probably between 100 and 200 m in thickness.

Pfaffenkogel Member: White biolaminated dolomites with birdseye-structures, thick bedded dolomites; up to 200 m in thickness.

**Underlying unit(s):** Presumably Semriach Formation and Taschen Formation.

**Overlying unit(s):** Schöckel Formation (tectonic contact).

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 133 Leoben, 134 Passail, 135 Birkfeld, 163 Voitsberg, 164 Graz, 165 Weiz.

**Remarks:** -

**Complementary references:** RANTITSCH et al. (1998), EBNER et al. (2000).

### Hochschlag-Formation / Hochschlag Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by E. FLÜGEL (1957: "Hochschlagserie" and "Hochschlagkalke"); formalized by FLÜGEL (2000: p. 43; Hochschlag-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined, but FLÜGEL (2000) selected a type region at Hochschlag, northeast of St. Erhard (Breitenau); ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail) (N 47°24'11" / E 15°30'17").

**Reference section(s):** -

**Derivation of name:** After Hochschlag (1,580 m), a mountain northeast of the Breitenau valley, approx. 55 km north of Graz.

**Synonyms:** Partly: Kalkschieferstufe i. A. (WAAGEN, 1937); Kalkzug der Brandlucke (NEUBAUER, 1982).

**Lithology:** Predominantly platy to slaty limestones with intercalations of black argillaceous shales, calcareous phyl-lites, whitish dolomites and metavolcanites.

**Fossils:** Rare rugose and tabulate corals.

**Origin, facies:** Shallow marine offshore environment.

**Chronostratigraphic age:** Presumably Emsian–Eifelian or Givetian.

**Biostratigraphy:** -

**Thickness:** More than 200 m.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** ?Weizbauer Member of the Schönberg Formation.

**Overlying unit(s):** Dornerkogel Formation (tectonic contact).

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 165 Weiz.

**Remarks:** -

**Complementary references:** -

## Raasberg-Formation / Raasberg Formation

(not shown in the ASC 2004)

BERNHARD HUBMANN

**Validity:** Valid; first description by FLÜGEL & MAURIN (1956: “gelbe Gesteinsserie”), resp. FLÜGEL (1961: “Raasberg-Folge”); formalized by FLÜGEL (2000: p. 41; Raasberg-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 165 Weiz).

**Type section:** FLÜGEL (2000) selected a type region at Raasberg, east of ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 165 Weiz) (N 47°15'01" / E 15°39'37").

**Reference section(s):** -

**Derivation of name:** After “Raasberg” (1,009 m), a mountain east of Weiz, approx. 48 km east of Graz.

**Synonyms:** Gelbe Gesteinsserie (FLÜGEL & MAURIN, 1956); “fragliche Triasserie” (FLÜGEL & MAURIN, 1957a); “triasverdächtige Gesteine” (FLÜGEL & MAURIN, 1957b); partly: Grenzzone (KUNTSCHNIG, 1927).

**Lithology:** Sericitic quartzites, yellow platy limestones and white to light grey dolostones.

**Fossils:** Unknown.

**Origin, facies:** Shallow marin ?

**Chronostratigraphic age:** Presumably Pragian–Eifelian.

**Biostratigraphy:** -

**Thickness:** Up to 500 m.

**Lithostratigraphically higher rank unit:** Peggau Group.

**Lithostratigraphic subdivision:** FLÜGEL & MAURIN (1957a) recognized four lithofacial types which were considered as members by FLÜGEL (2000), i.e., Egg Member, Häulerkreuz Member, Lammkogel Member and Stroß Member.

Egg Member: Light grey to white dolomites with local intercalations of quartzites and dolomitic limestones; at least 250 m in thickness reddish-purple to green volcanics within grey to bluish dolostones; about 50 m (up to 200 m) in thickness.

Häulerkreuz Member: Light blue to bluegrey, coarse grained limestones and dolomites, yellow sericitic quartzites and metatuffs; thickness unknown.

Lammkogel Member: Yellow to light grey quartzites and quartzitic slates; 100 to 200 m in thickness.

Stroß Member: White to light reddish dolomites and light grey limestones with cellular dolomites, subordinate greenstones; up to 200 m in thickness.

**Underlying unit(s):** Crystalline rocks tectonically underlying the Graz Paleozoic.

**Overlying unit(s):** Schöckel Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 162 Köflach, 163 Voitsberg, 164 Graz, 165 Weiz.

**Remarks:** CLAR (1933) compared the succession with Lower Devonian sequences of the Rannach Nappe, whereas FLÜGEL & MAURIN (1956, 1957a, b) and H. FLÜGEL (1961, 1975) supposed a possible Mesozoic (?Triassic) age.

**Complementary references:** -

## Schöckel-Formation / Schöckel Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by CLAR (1874: Schöcklkalk); formalized by FLÜGEL (2000: p. 42; Schöckelkalk-Formation; change of name into Schöckel-Formation by EBNER et al. (2001).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) selected as type region the Schöckel, a mountain north of Graz, ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz) (N 47°11'54" / E 15°27'55").

**Reference section(s):** -

**Derivation of name:** After Schöckel (1,445 m), a mountain north of Graz (mind the variations in spelling of the mountain through time, Schöckl vs. Schöckel).

**Synonyms:** Peggauer Kalk (STANDFEST, 1881); Kalke des Raasberggipfel (MAURIN & FLÜGEL, 1958).

**Lithology:** Blue-white, mostly well-bedded banded limestones.

**Fossils:** -

**Origin, facies:** Presumably offshore shallow environment.

**Chronostratigraphic age:** Presumably Eifelian–Givetian.

**Biostratigraphy:** -

**Thickness:** Several (?) hundreds of meters.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Schönberg Formation, Raasberg Formation.

**Overlying unit(s):** -

**Lateral unit(s):** Hochschlag Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 133 Leoben, 134 Passail, 162 Köflach, 163 Voitsberg, 164 Graz, 165 Weiz.

**Remarks:** SEELMEIER (1941) discerned three lithological types, grey-blue “semi-metamorphic” limestones, pure white limestones, and white-grey to grey-blue mostly well banded limestones.

**Complementary references:** EBNER et al. (2000).

## Hackensteiner-Formation / Hackensteiner Formation

BERNHARD HUBMANN

**Validity:** Valid; first description and formalization by GOLLNER et al. (1982: p. 64–69).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** The type sections between Laufnitzdorf and south of St. Jakob (N 47°08'56" / E 15°23'33") were described by GOLLNER et al. (1982).

**Reference section(s):** -

Remarks: GOLLNER et al. (1982) distinguished three series within the formation which were re-named and considered as members by FLÜGEL (2000).

**Derivation of name:** After the farmstead Hackensteiner north of Laufnitzdorf (Frohnleiten).

**Synonyms:** Partly: Orthocerenkalk (FLÜGEL, 1953a); Folge von Laufnitzdorf (H. FLÜGEL, 1960, 1975).

**Lithology:** Succession of various fine-grained volcaniclastic rocks, organodetrritic limestones and silt- to sandstones.

**Fossils:** Conodonts; TSCHELAUT in GOLLNER et al. (1982) mentioned in the lower series (basal 30 m of the sequence) various fossils in thin sections (bryozoans, brachiopods, echinoderms, trilobites).

**Origin, facies:** Pelagic environment of some 10 to 100 m water depth (GOLLNER et al., 1982).

**Chronostratigraphic age:** Llandovery to Emsian.

**Biostratigraphy:** *amorphognathoides* Zone–lower *sagitta* Zone.

**Thickness:** About 350 m.

**Lithostratigraphically higher rank unit:** Laufnitzdorf Group (FLÜGEL, 2000)

**Lithostratigraphic subdivision:** FLÜGEL (2000) discerned three members according to the suggestions of GOLLNER et al. (1982).

Oberferler Member: Predominantly argillaceous shales and silt/sandstones, subordinate occurrences of lydites and alkaline volcanoclastics; up to 200 m in thickness.

Rathlosgraben Member: Flaser to nodular limestones, argillaceous shales, Lydites and silt/sandstones; up to 90 m in thickness.

Rothleiten Member: Alkaline volcanoclastics with intercalations of limestones; about 70 m in thickness.

**Underlying unit(s):** Formations of the Hochschlag and Gschwend Nappes (tectonic contact).

**Overlying unit(s):** Units of the Kogler Nappe (tectonic contact).

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 133 Leoben, 134 Passail.

**Remarks:** -

**Complementary references:** FLÜGEL & NEUBAUER (1984), HUBMANN & WEBER (2010).

### Kehr-Formation / Kehr Formation

BERNHARD HUBMANN

**Validity:** Valid; description and formalization by FLÜGEL (2000: p. 14; “Kehrer-Vulkanit-Formation”); change of name into Kehr-Formation by EBNER et al. (2000).

**Type area:** ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** No type section defined, but FLÜGEL (2000) proposed a type region in the municipality area of Kehr, ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg) (N 47°07'38" / E 15°14'34").

**Reference section(s):** -

**Derivation of name:** After Kehr (formerly Kher), a small village east of the monastery Rein, approx. 20 km northwest of Graz.

**Synonyms:** Partly: obere Schiefer (HERITSCH, 1917b); Falbenschiefer (WAAGEN, 1929); untere Schichten von Kher

(FLÜGEL & SCHÖNLAUB, 1972b; FLÜGEL & NEUBAUER, 1984); Schichten von Kher (H. FLÜGEL, 1975); vulkanoklastische Schichtfolge des Haritzgrabens (NEUBAUER, 1989).

**Lithology:** Predominantly alkaline subordinately acidic metavolcanites (tuffs, lavas).

**Fossils:** Conodonts – one single finding of a graptolite fragment (HIDEN, 1995).

**Origin, facies:** Open marine environment.

**Chronostratigraphic age:** Llandovery–Ludlow.

**Biostratigraphy:** *leintwardinensis* graptolite zone.

**Thickness:** Probably more than 100 m.

**Lithostratigraphically higher rank unit:** Reinerspitz Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Unknown (crystalline basement of the Graz Paleozoic ?)

**Overlying unit(s):** Kötschberg Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 163 Voitsberg, 164 Graz.

**Remarks:** -

**Complementary references:** HUBMANN & MESSNER (2005).

### Kötschberg-Formation / Kötschberg Formation

BERNHARD HUBMANN

**Validity:** Valid; description and formalization by FLÜGEL (2000: p. 14; “Kötschberger-Formation”); change of name into Kötschberg-Formation by EBNER et al. (2000).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) proposed a type region in the area of the municipality Kötschberg; ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz) (N 47°05'28" / E 15°20'56").

**Reference section(s):** -

**Derivation of name:** After Kötschberg near Thal, a small village 12 km west of Graz.

**Synonyms:** Partly: obere Schiefer (HERITSCH, 1917b); obere Schichten von Kher (FLÜGEL & SCHÖNLAUB, 1972b; FLÜGEL & NEUBAUER, 1984); Schichten von Kher (H. FLÜGEL, 1975); plattige Kalkschiefer (WEBER, 1990).

**Lithology:** Predominantly limestones, rare dolostones, argillaceous shales and silty shales.

**Fossils:** Conodonts, orthocon cephalopods, bivalves, corals.

**Origin, facies:** Pelagic environment.

**Chronostratigraphic age:** Ludlow–Lochkovian.

**Biostratigraphy:** *siluricus* to *woschmidtii* conodont zones.

**Thickness:** About 30 m.

**Lithostratigraphically higher rank unit:** Reinerspitz Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** FLÜGEL (2000) distinguished 4 members:

Eggenfeld Member: Dolomites alternating with fine bedded tuffs; about 10 m in thickness.

Genovevakreuz Member: Brownish to grey flaser limestones and nodular limestones; about 10 m in thickness.  
Lend Member: Red to violet sometimes brecciated dolomites and dolomitic phyllites and platy limestones; known only from temporarily exposed subsurface outcrops.  
Thalwinkel Member: Red to violet cephalopod limestones; up to 30 m in thickness.

**Underlying unit(s):** Kehr Formation.

**Overlying unit(s):** Parmasegg Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 163 Voitsberg, 164 Graz.

**Remarks:** -

**Complementary references:** HUBMANN & MESSNER (2005, 2007), HUBMANN & SUTTNER (2007), HISTON et al. (2010), EBNER & HUBMANN (2012).

### Bameder-Formation / Bameder Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by EBNER (1989: "Bameder-Formation"); formalized by EBNER (1998: p. 129–130).

**Type area:** ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** Not defined, but EBNER (1998) proposed a type region at Bamederkogel (1,160 m) (N 47°11'45" / E 15°12'20") west of village Groß-Stübing (ÖK50-BMN, map sheet 163 Voitsberg).

**Reference section(s):** -

**Derivation of name:** After the hill Bameder 30 km north of Graz.

**Synonyms:** Partly: Bythotrephis-Schiefer (STACHE, 1874); Neritenschiefer (PENECKE, 1894); Nereitenschiefer (HERITSCH, 1906); Scalarituba-Sandsteine (WEBER, 1990).

**Lithology:** Grey sand/siltstones and clay shales with intercalations of black platy nodular and flaser limestones.

**Fossils:** Rare solitary rugose corals.

**Origin, facies:** Intertidal to shallow subtidal environment.

**Chronostratigraphic age:** Lochkovian–Pragian.

**Biostratigraphy:** -

**Thickness:** 300–500 m.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** EBNER (1998) distinguished 2 members, both outcropping on Bameder hill west of Groß-Stübing.

Krahfuß Member: Predominantly grey sandstones with *Scalarituba* and intercalations of dark coloured platy (crinoidal) limestones; about 150–200 m in thickness.

Spandl Member: Succession overlying the Krahfuß Member; alternating silty and clayey shales and sand/siltstones with darkgrey platy limestones; about 200–300 m in thickness.

**Underlying unit(s):** Unknown.

**Overlying unit(s):** Unknown.

**Lateral unit(s):** -

**Geographic distribution:** Styria, western parts of highland in the surroundings of Graz; ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Remarks:** -

**Complementary references:** EBNER (2001), FLÜGEL (2000).

### Heigger-Formation / Heigger Formation

BERNHARD HUBMANN

**Validity:** Valid; first abridged description by FLÜGEL (1984) (herein: "Haiggerfolge"); formalized by FLÜGEL (2000: p. 23; Heigger-Formation).

**Type area:** ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** No type section defined; FLÜGEL (1984, 2000) proposed an area between the western slopes of Pleschkogel (1,061 m) and Mühlbacherkogel (1,050 m) as type region (Heiggerkogel: N 47°09'34" / E 15°14'20").

**Reference section(s):** -

**Derivation of name:** After the hill Heiggerkogel (1,098 m) northwest of Rein.

**Synonyms:** Partly: Kalkschieferstufe i.w.S. (HERITSCH, 1917b, c).

**Lithology:** Light grey to brownish thin bedded limestones locally intercalated by marly clay/siltstones.

**Fossils:** Spicules, styliolids, conodonts (BUCHROITHNER, 1978).

**Origin, facies:** Shallow subtidal deposits.

**Chronostratigraphic age:** Lochkovian–Emsian.

**Biostratigraphy:** -

**Thickness:** Local strong variation in thickness; more than 100 m.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Parmasegg Formation.

**Overlying unit(s):** Flösserkogel Formation.

**Lateral unit(s):** Flösserkogel Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz.

**Remarks:** Transitions from dolomitic and sandy/silty deposits of the Flösserkogel Formation into successions dominated by thin bedded limestones northwest of Pleschkogel-Heiggerkogel-Mühlbacherkogel were interpreted as transitional zone between tidal flat environments and basinal settings (FENNINGER & HOLZER, 1978) of the "Rannachfacies" (H. FLÜGEL, 1975).

**Complementary references:** EBNER (1998, 2001).

### Parmasegg-Formation / Parmasegg Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by FLÜGEL (1960: "Crinoiden-Schichten"); formalized by FRITZ (1991: p. 230–233; Parmasegg Formation).

**Type area:** ÖK50-UTM, map sheet 4222 Leoben (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** FRITZ (1991) proposed a type section at Parmaseggkogel (N 47°13'29" / E 15°28'50").

**Reference section(s):** Greitnerkogel (N 47°12'55" / E 15°17'25") (FRITZ, 1991).

**Derivation of name:** After the hill Parmasegg (785 m) 28 km north of Graz (FRITZ, 1991).

**Synonyms:** Crinoiden-Schichten (H. FLÜGEL, 1960, 1961, 1975); partly: Kalkschiefer-Folge (CLAR, 1874); unterer Crinoidenkalk (HOERNES, 1880); Kalkschieferstufe (HERITSCH, 1906); Kalkschieferstufe i.A. (WAAGEN, 1937); Plattenkalke und Schiefer des e-gamma (SEELMEIER, 1944); ef-Flaser-Plattenkalke (SCHOUPE, 1953); plattige Kalkschiefer (WEBER, 1990).

**Lithology:** Major parts of the succession consist of platy crinoidal limestones intercalated with sandy marls and sand/siltstones.

**Fossils:** Fossils are rare (conodonts, badly preserved rugose corals, indeterminable crinoids).

**Origin, facies:** Intertidal to shallow subtidal environment.

**Chronostratigraphic age:** Pragian (may locally also contain uppermost Silurian (*eosteinhornensis* conodont zone); FRITZ, 1991: p. 232)–lower Emsian (?).

**Biostratigraphy:** See above.

**Thickness:** 150–200 m.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** FRITZ (1991) distinguished four members (Dolomit-Siltschiefer Member, Karbonat-Mergel Member, Plattenkalk Member and Siltstein Member) in the type region. FLÜGEL (2000) divided the formation into three members:

Greitnerkogel Member: Blue-grey platy limestones and crinoidal limestones; less than 100 m in thickness.

Oberbichl Member: Succession of brown platy silty limestones, flaser- and crinoid-limestones, and sand/siltstones; some tens of meters in thickness.

Stiwoll Member: Yellowish marly sand/siltstones; about 80 m in thickness.

**Underlying unit(s):** Kötschberg Formation.

**Overlying unit(s):** Flösserkogel Formation.

**Lateral unit(s):** Bameder Formation, Heigger Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 163 Voitsberg, 164 Graz.

**Remarks:** -

**Complementary references:** HUBMANN & MESSNER (2007).

### Kogler-Formation / Kogler Formation

BERNHARD HUBMANN

**Validity:** Valid; first nomination by GOLLNER & ZIER (1985: "Koglerformation"), formalized by FLÜGEL (2000: p. 43; Kogler-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined, but FLÜGEL (2000) selected a type region in the vicinity of the farmstead "Kogler", south of St. Erhard, ÖK50-BMN, map sheet 134 Passail (N 47°22'43" / E 15°27'13").

**Reference section(s):** -

**Derivation of name:** After the farmstead "Kogler", south of St. Erhard (Breitenau valley), approx. 55 km north of Graz.

**Synonyms:** Partly: Kalkschiefer-Folge (CLAR, 1874); Kalkschieferstufe i. A. (WAAGEN, 1937).

**Lithology:** Darkblue to darkgrey, platy and banded limestones, locally with sandstone alternations.

**Fossils:** Conodonts; rare tabulate and rugose corals.

**Origin, facies:** Shallow marine deposits.

**Chronostratigraphic age:** Due to the lack of stratigraphically meaningful fossils no exact age determinable; presumably Lower to Middle Devonian (?Upper Devonian).

**Biostratigraphy:** -

**Thickness:** Up to 800 m.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** FLÜGEL (2000) distinguished three members:

Geschwend Member: Alternating limestones, silt- to sandstones and subordinate argillaceous shales and dolomites, locally volcanites; up to 800 m (?) in thickness.

Sattelbauer Member: Lightgrey, locally fossiliferous limestones (corals, brachiopods) with chert nodules; thickness about 150 m.

Spatl Member: Reddish to violet micritic (flaser) limestones, sandstone and argillaceous shales with intercalations of thin-bedded alkaline volcanoclastics; about 100 m in thickness.

**Underlying unit(s):** In the area east of the Hochlantsch and the basin of Passail the Kogler Formation is underlain by the Rauchenberg Member of the Schönberg Formation.

**Overlying unit(s):** North of the Tyrnaueralm successions of the Laufnitzdorf Nappe overlying the Kogler Formation, whereas south of the Tyrnaueralm the formation is overlain by successions of the Schöckel Nappe.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 133 Leoben, 134 Passail, 163 Voitsberg.

**Remarks:** Lithological content of the formation is very similar to the Hochschlag Formation and the Hubenhalt Formation respectively (FLÜGEL, 2000).

**Complementary references:** EBNER (1998).

### Hubenhalt-Formation / Hubenhalt Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by PENECKE (1890: "Kalke und Kalkschiefer der Hubenhalt"), formalized by FLÜGEL (2000: p. 44–45; Hubenhalt-Formation).

**Type area:** Hubenhalt northwest of Fladnitz (Teichalpe area), ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined. FLÜGEL (2000) selected a type region at Hubenhalt, northwest of Fladnitz ÖK50-BMN, map sheet 134 Passail (N 47°19'15" / E 15°26'40"), approx. 40 km north of Graz.

**Reference section(s):** -

**Derivation of name:** After Hubenhalt an area east of Tyrnau, approx. 40 km north of Graz.

**Synonyms:** Kalke und Kalkschiefer der Hubenhalt (PENECKE, 1890); Kalkschiefer der Hubenhalt (CLAR et al., 1929); Schichten der Hubenhalt (H. FLÜGEL, 1975).

**Lithology:** Various platy to slaty limestones and dolomites with sandstone intercalations.

**Fossils:** Conodonts and corals.

**Origin, facies:** Deeper marine environment with restricted water circulation (HUBAUER, 1986).

**Chronostratigraphic age:** Pragian–Emsian.

**Biostratigraphy:** -

**Thickness:** 130–250 m.

**Lithostratigraphically higher rank unit:** Peggau Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** HUBAUER (1986) distinguished four formations within the “Kalkschieferformationen” between Tyrnauergraben and Schremsbach (Hochlantsch area, west of Passail basin); FLÜGEL (2000) adopted HUBAUER’s subdivisions but changed their hierarchy into members.

Gscheidberg Member: Brownish, limonitic limestones and subordinate alkaline metatuffs; up to 200 m in thickness.

Hausebner Member: Alternating crinoidal limestones, flaser limestones, marly siltstones and calcareous sandstones, subordinate dolostones and tuffitic shales; thickness up to 250 m.

Heuberg Member: Grey to brown flaser limestones, dolomitic marls and slaty sandstones; about 200 m in thickness.

Sulberg Member: Blue-grey (flaser)limestones, sandstone with frequent intercalations of dolostones and carbonatic sandstones; up to 130 m in thickness.

**Underlying unit(s):** Unknown due to tectonic cut.

**Overlying unit(s):** Plabutsch Formation, Tyrnaueralm Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** FLÜGEL & HUBAUER (1984).

### Harrberger-Formation / Harrberger Formation

BERNHARD HUBMANN

**Validity:** Valid; first description and formalization by GOLLNER (1981: p. 62; Harrberger-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** GOLLNER (1981) published five sections (A–D) at the northern slope of the Hochlantsch in the vicinity of the farmstead “Harrberger” south of Breitenau valley (N 47°22’15” / E 15°26’10”). Section A at altitude 1,015 and 1,230 m was chosen as type section by GOLLNER (1981).

**Reference section(s):** In the vicinity of the farmstead Harrberger GOLLNER (1981) described four reference sections of the formation, section B at 1120 to 1185 m altitude, section C at 1,100 and 1,240 m and section D at

1,135 and 1,200 m; section E is along a forest road at 1,150 m altitude.

**Remarks:** GOLLNER et al. (1982) distinguished three series within the formation which were re-named and considered as members by FLÜGEL (2000).

**Derivation of name:** After the abandoned farmstead Harrberger south of the Breitenau valley, approx. 55 km north of Graz.

**Synonyms:** Partly: Bänderkalk-Kalkschiefer-Zug (CLAR et al., 1929).

**Lithology:** Limestones with tentaculites, argillaceous shales, sandstones, lydites, radiolarites and tuffs.

**Fossils:** Conodonts, tentaculites, radiolarians.

**Origin, facies:** Calm pelagic environment of some 10 to 100 m water depth (GOLLNER, 1981).

**Chronostratigraphic age:** Emsian–Frasnian; not Eifelian as indicated in the ASC 2004.

**Biostratigraphy:** *gronbergi* to *triangularis* conodont zones.

**Thickness:** 70–90 m.

**Lithostratigraphically higher rank unit:** Laufnitzdorf Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Formations of the Gschwend Nappes (tectonic contact).

**Overlying unit(s):** Formations of the Osser and Hochlantsch Nappe (tectonic contact).

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** GOLLNER & ZIER (1982), FLÜGEL & NEUBAUER (1984).

### Flösserkogel-Formation / Flösserkogel Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by PENECKE (1894: “Quarzit-Dolomit-Stufe”); formalized by FLÜGEL (2000: p. 19; Flösserkogel-Formation).

**Type area:** ÖK50-UTM, map sheets 4223 Weiz, 4228 Voitsberg, 4229 Graz (ÖK50-BMN, map sheets 134 Passail, 162 Köflach, 163 Voitsberg, 164 Graz).

**Type section:** No type section defined; FENNINGER & HOLZER (1978) published several dislocated sections; FLÜGEL (2000) proposed a type region at Flösserkogel (elevation spot 696 m on ÖK50-BMN, map sheet 164 Graz) (N 47°06’15” / E 15°22’06”).

**Reference section(s):** Following sections studied by FENNINGER & HOLZER (1978) may be used for reference: Göstinggraben (N 47°06’01” / E 15°22’49”), Pfaffenkogel (N 47°09’54” / E 15°19’02”) (see also HUBMANN & MESSNER, 2005), Eichberg (N 47°06’54” / E 15°22’47”), and Trefenberg (Treffenkogel, 745 m) (N 47°09’07” / E 15°16’38”).

**Remarks:** This formation covers large areal parts in the Rannach Nappe but lacks good outcrops due to its high weathering capability; in the Hochlantsch Nappe the thickness is reduced due to tectonic amputation.



**Derivation of name:** After the hill Flösserkogel northwest of Graz (FLÜGEL, 2000).

**Synonyms:** Quarzit-Dolomit-Stufe (PENECKE, 1894); Dolomit-Sandstein-Folge (Stufe) (HERITSCH, 1917b, c); Dolomitsandstein-Folge (H. FLÜGEL, 1953a, 1961, 1975; FENNINGER & HOLZER, 1978; EBNER et al., 1980a, b).

**Lithology:** Major parts of the succession consist of monotonous light grey late diagenetic dolostones. In some sections in the vicinity of Graz and west of the Pleschkogel various lithotypes in different stratigraphic levels occur: reddish-purple to green volcanoclastics, pure quartz sandstones, marly dolomites, biolaminated and bioclastic dolomites of variable colors.

**Fossils:** Fossils are rare; bad preserved rugose and tabulate corals and stromatoporoids are restricted to few localities. At Admonterkogel and Rannach hill amphiporid mounds (*Amphipora ramosa desquamata*) occur (HUBMANN & SUTTNER, 2007). For faunal list see H. FLÜGEL (1975).

**Origin, facies:** Parts of the successions with biolaminations, fenestrate fabrics and gypsum pseudomorphs are interpreted as tidal flat deposits.

**Chronostratigraphic age:** Pragian to Emsian; locally Eifelian (to Givetian?).

**Biostratigraphy:** -

**Thickness:** 500–1,000 m, local strong variation in thickness.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** FENNINGER & HOLZER (1978) distinguished four facial types which were considered as members by FLÜGEL (2000), i.e., Göstinggraben Member, Pfaffenkogel Member, Treffenberg Member and Eichberg Member. Following the conception of FLÜGEL (2000) four further members are to be added: Admonterkogel Member (FLÜGEL, 2000), Pleschkogel Member (EBNER, 1998), Schwarzkogel Member (FLÜGEL, 2000), and Sattler Member (FLÜGEL, 2000). HUBMANN (2003) supplemented the Kehlberg Member.

Admonterkogel Member: Reddish-purple to green volcanoclastics within grey to bluish dolostones; about 50 m (up to 200 m) in thickness.

Eichberg Member: Interbeddings of black dolomitic *Amphipora* float/packstones and platy, sometimes laminated darkgrey dolomites; strong variation in thickness (less than 100 m).

Göstinggraben Member: White to yellow sandy dolomites intercalated with quartzitic silt/sandstones and platy dolomites; probably some 100 m in thickness.

Kehlberg Member: Brown cellular dolomites and shales; probably some 10 m in thickness.

Pfaffenkogel Member: White biolaminated dolomites with birdseye-structures, thick bedded dolomites; up to 200 m in thickness.

Pleschkogel Member: Well bedded dolomites in intercalation with darkblue biotrititic limestones; strong variation in thickness (several tens of meters).

Sattler Member: Darkblue, local biotrititic dolostones with subordinate dolomitic shales and sandstone intercalations; about 500 m in thickness.

Schwarzkogel Member: Massive to platy sand/siltstones with yellow weathering color; probably some 100 m in thickness.

Treffenberg Member: Grey to lightbrown marly dolomites and flaserdolomites; probably up to 100 m in thickness.

**Underlying unit(s):** Parmasegg Formation.

**Overlying unit(s):** Plabutsch Formation.

**Lateral unit(s):** Parmasegg Formation, Plabutsch Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz.

**Remarks:** -

**Complementary references:** HUBMANN (1993), HUBMANN & MESSNER (2007), EBNER & HUBMANN (2012).

### Plabutsch-Formation / Plabutsch Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by PENECKE (1890: "Horizont des *Heliolites Barrandei*"); formalized by HUBMANN (1993: Barrandeikalk-Formation), FLÜGEL (2000: Barrandeikalk-Formation) and HUBMANN (2003: Plabutsch-Formation).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** The type section along the forest road (N 47°05'20" / E 15°22'12") at the southern slope of the Frauenkogel (near Thalwinkel) was described by HUBMANN (1992, 1993).

**Reference section(s):** Reference sections within the Rannach Nappe, the Hochlantsch Nappe and the "transitional zone" are named by HUBMANN (1993): the abandoned quarry at Kollerkogel (N 47°03'31" / E 15°22'29") from the Plabutsch-Buchkogel-Range, the section along the road south of St. Pankrazen (N 47°07'56" / E 15°11'04"), and in the Hochlantsch area the section along the forest road to Tyrnaueralm (N 47°20'10" / E 15°25'02") and the abandoned quarry in the vicinity of the hotel "Pierer" at Teichalm.

Remarks: Type area and eponym is the Plabutsch, a hill which supplied in several quarries huge amounts of building material for the city of Graz during the 19<sup>th</sup> century. Today, the ancient quarries are covered by vegetation and no persistent sections are known from that area. The formation occurs in the Rannach Nappe as well as in the Hochlantsch Nappe.

**Derivation of name:** After the hill Plabutsch (754 m) west of Graz (HUBMANN, 2003).

**Synonyms:** During history of investigation the succession has been called "Barrandeikalk" (PENECKE, 1890; derived from a heliolid coral's species name) for more than 110 years. Attempts to subdivide the formation into a coral-dominated lower part and a brachiopod-rich upper part resulted in a subdivision of "Korallenkalk" and "Pentameruskalk" (HERITSCH, 1935). Both terms and definitions are only applicable in some distinct regions and were therefore dismissed. Other older synonyms: Korallenbank des Plabutsch (PETERS, 1867); Kalk des Gaisberges (Suess, 1868); Korallenkalk (CLAR, 1874); Horizont des *Heliolites Barrandei* (PENECKE, 1890); Barrandeikalk (H.

FLÜGEL, 1961, 1975); Barrandeikalk-Formation (HUBMANN, 1993; FLÜGEL et al., 2011). During evaluation of the conceptual content of the formation and re-definition (HUBMANN, 2003: p. 285–287) the Draxler-Formation (sensu FLÜGEL, 2000: p. 25; equivalent to “unterer Schweineggkalk” of ZIER, 1982) was synonymised with the Plabutsch Formation.

**Lithology:** The succession represents a highly fossiliferous sequence dominated by dark marly bioclastic limestones. In the lower parts, especially at the boundary to the underlying Flösserkogel Formation yellow to brownish shales occasionally blotched with moulds of chonetid brachiopods are characteristic. In the upper parts of the formation intercalations of red marls and marly limestones are common.

**Fossils:** Coral and sponge taxa dominate the diverse fauna. Among tabulate corals most common are thamnoporids (*Thamnopora reticulata*, *Th. vermicularis*, “*Striatopora suessi*”), favositids (*Favosites styriacus*, *F. alpinus*), and heliolitids (*Pachycanalicula barrandei*). The rugose coral fauna is dominated by mostly fractured dendroid (phaceloid) taxa. A frequent and distinctive phillipsastroid taxon is *Thamnophyllum* (*Th. stachei*, *Th. murchisoni*). Stromatoporoids are mostly recrystallized and thus precluding precise determinations (common genera are *Actinostroma* and *Clathrocoilona*). Among brachiopods the thick valved *Zdimir* cf. *hercynicus* may occur in coquina horizons. For faunal list see H. FLÜGEL (1975: p. 44–46).

**Origin, facies:** A deposition on a differentiated and gently inclined carbonate platform of some few (tens) meters is assumed (HUBMANN, 1993). Conspicuous is the rarity of in situ organisms, the intermittently high supply of clayey sediments (marl-limestone intercalations) and high supply of lime mud, temporary influx of high amounts of continental phytoclasts and storm impacts (tempestites) (HUBMANN, 1995).

**Chronostratigraphic age:** Eifelian; locally the sequence may range from Upper Emsian to Lower Givetian (HUBMANN, 1993).

**Biostratigraphy:** -

**Thickness:** 80–100 m, strong variation.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** In some sections at the base of the unit less than 5 m thick brownish to yellow marly slates with moulds of chonetid brachiopods are named Gaisberg Bed (FLÜGEL, 2000; HUBMANN & FRITZ, 2004; HUBMANN & MESSNER, 2007).

**Underlying unit(s):** Flösserkogel Formation (conformable contact, transgressive).

**Overlying unit(s):** Kollerkogel Formation (conformable contact).

**Lateral unit(s):** Flösserkogel Formation, Kollerkogel Formation, Tyrnaueralm Formation, Osser Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 162 Köflach, 163 Voitsberg, 164 Graz.

**Remarks:** -

**Complementary references:** EBNER & HUBMANN (2012).

## Osser-Formation / Osser Formation

BERNHARD HUBMANN

**Validity:** Valid; first entry by VACEK (1891: “Osserkalk”); formalized by FLÜGEL (2000: p. 25; Osser-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** Not defined, but FLÜGEL (2000) defined the hill Osser (N 47°20'40" / E 15°30'03") north of Passail as type region.

**Reference section(s):** -

**Derivation of name:** After the hill Osser (1,548 m) north of Graz (FLÜGEL, 2000).

**Synonyms:** Partly: Kalkschiefer [Folge] (CLAR, 1874; HERITSCH, 1917c); Flaserkalk (Osserkalk) (CLAR et al., 1929); Kalkschiefer-Stufe im Allgemeinen (WAAGEN, 1937); Kalkschiefer-Folge (H. FLÜGEL, 1961, 1975).

**Lithology:** Bluish platy tectonically stressed flaser limestones and grey dolostones with local intercalations of marly clay/siltstones and sandstones.

**Fossils:** Bad preserved rugose and tabulate corals.

**Origin, facies:** Shallow subtidal environment.

**Chronostratigraphic age:** ?Eifelian.

**Biostratigraphy:** -

**Thickness:** 50–100 m.

**Lithostratigraphically higher rank unit:** Rannach Group (FLÜGEL, 2000, p. 25).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flösserkogel Formation.

**Overlying unit(s):** Tyrnaueralm Formation?

**Lateral unit(s):** Plabutsch Formation?

**Geographic distribution:** Styria, highland in the surroundings of Graz, southeast of the Teichalm; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** STATTEGGER (1984).

## Schweinegg-Formation / Schweinegg Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by ZIER (1982: “oberer Schweineggkalk”); formalized by FLÜGEL (2000: p. 35–36; Schweinegg-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined, but FLÜGEL (2000) appointed the Schweinegg (= Schweineck, 1,457 m), a hill southwest of Teichalmhütte in the Hochlantsch area as type region (N 47°20'52" / E 15°26'40").

**Reference section(s):** -

**Derivation of name:** After a hill called Schweinegg in the Hochlantsch region, approximately 55 km north of Graz.

**Synonyms:** Oberer Schweineggkalk (ZIER, 1982).

**Lithology:** Dark grey to brown fossiliferous limestones.

**Fossils:** Stromatoporoids, rugose and tabulate corals, crinoids (see ZIER, 1982).

**Origin, facies:** Subtidal depositional environment with minor terrigenous influx.

**Chronostratigraphic age:** Eifelian, Givetian?

**Biostratigraphy:** -

**Thickness:** Less than 100 m.

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flösserkogel Formation (with tectonic contact).

**Overlying unit(s):** Tyrnaueralm Formation.

**Lateral unit(s):** Zachenspitz Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** Parts of this formation which contain corals and stromatoporoids resemble the Plabutsch Formation resp. the Tyrnaueralm Formation of the Rannach Group. ZIER (1982) distinguished two parts within the sequence, a lower up to 60 m thick part of the succession which contains considerable amounts of stromatoporoids and corals and an upper part with white fossil-free beds of limestones. FLÜGEL (2000) assigned ZIER's lower part of the formation ("unterer Schweineggkalk") to the Draxler Formation which was synonymised with the Plabutsch Formation by HUBMANN (2003).

**Complementary references:** GOLLNER & ZIER (1985).

### Rotmüller-Formation / Rotmüller Formation

BERNHARD HUBMANN

**Validity:** Valid; first description and formalization by EBNER (1998: p. 128).

**Type area:** ÖK50-UTM, map sheet 4222 Leoben (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** No type section published because of bad outcrops; according to EBNER (1998) on both sides of the Arzbach valley from "Reicherhöhe" (998 m; N 47°12'24" / E 15°14'23") in the southwest to "Rathlosgraben" in the northeast and in the vicinity of the farmstead "Rotmüller" (N 47°14'54" / E 15°14'52") on ÖK50-BMN, map sheet 163 Voitsberg typical outcrops of the formation may be seen.

**Reference section(s):** See above; forest road west of Reicherhöhe at altitude 880 m (EBNER, 1998)

**Remarks:** The Formation may be a lateral equivalent of the Tyrnaueralm Formation (EBNER, 1998: p. 128).

**Derivation of name:** After the farmstead "Rotmüller" 40 km northwest of Graz.

**Synonyms:** -

**Lithology:** Massive light to dark grey dolostones.

**Fossils:** Stromatoporoids (especially amphiporids), rugose and tabulate corals, crinoids, brachiopods.

**Origin, facies:** Subtidal depositional environment.

**Chronostratigraphic age:** ?Eifelian – Givetian.

**Biostratigraphy:** -

**Thickness:** About 300 m.

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Flösserkogel Formation (tectonic contact).

**Overlying unit(s):** Fahrneck Formation.

**Lateral unit(s):** Zachenspitz Formation?

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** FLÜGEL (2000).

### Kollerkogel-Formation / Kollerkogel Formation

BERNHARD HUBMANN

**Validity:** Valid; first entry by SUESS (1868: "ungeschichteter, ... lichtgrauer Kalkstein, welcher ... an den Westhängen des Kollerberges ... entblößt ist"); formalized by FLÜGEL (2000: p. 25–26; Kollerkogel-Formation).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) selected a type region at Kollerkogel (Kollerberg, 633 m) (N 47°03'46" / E 15°22'35"), a hill belonging to the Plabutsch-Buchkogel-Range west of Graz.

**Reference section(s):** -

**Derivation of name:** After the hill Kollerberg (633 m) west of Graz.

**Synonyms:** Helle Kalke (KUNTSCHNIG, 1937); Helle Kalke des Mitteldevon (SCHÄFER, 1937); partly: Korallenkalk (CLAR, 1874) and Mitteldevon-Gruppe (VACEK, 1891).

**Lithology:** Grey dolomites with biolaminations, light bluish limestones (mostly mudstones), locally bioclastic limestones with chert nodules.

**Fossils:** Rugose and tabulate corals, stromatoporoids, conodonts.

**Origin, facies:** Major parts of the sequence developed in an open platform setting; basal parts are shallow restricted lagoonal deposits due to biolaminations, emersion horizons and pseudomorphs after gypsum.

**Chronostratigraphic age:** Givetian–Frasnian.

**Biostratigraphy:** *varcus* Zone; *asymmetricus* to *triangularis* conodont zones.

**Thickness:** Strong variation in thickness; about 150 m.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** FLÜGEL (2000) included four members in the Kollerkogel Formation.

Gaisbergsattel Member: dark grey biolaminated dolostones; about 20 m (up to 100 m) in thickness.

Kanzel Member: light grey to bluish limestones; mostly mudstones; up to 100 m in thickness.

Platzl Member: sequence of grey limestones intercalated with carbonatic argillaceous shales; about 50 m in thickness.

Platzlkogel Member: grey limestones (in some places biohermal structures); about 75 m in thickness.

**Underlying unit(s):** Plabutsch Formation (conformable contact).

**Overlying unit(s):** Steinberg Formation (conformable contact).

**Lateral unit(s):** ?Plabutsch Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 163 Voitsberg, 164 Graz.

**Remarks:** FLÜGEL (2000) introduced the Kollerkogel Formation substitutional for the two former lithostratigraphic units “Kanzelkalk” (e.g., VACEK, 1907; H. FLÜGEL, 1975; EBNER et al., 1980a) and the “Mitteldevon-Dolomit” (EBNER et al., 1980a). In this conception both units have the rank of a member only.

**Complementary references:** HUBMANN (1993, 2003), HUBMANN & FRITZ (2004), HUBMANN & MESSNER (2007), HUBMANN & WEBER (2010), EBNER & HUBMANN (2012).

### Tyrnaueralm-Formation / Tyrnaueralm Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by GOLLNER & ZIER (1982: “Tyrnauer Alm-Formation”); formalized by GOLLNER & ZIER (1985: p. 48–49; Tyrnauer Alm-Formation); change of name into Tyrnaueralm-Formation by FLÜGEL (2000: p. 32).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** At forest road to Tyrnauer Alm east of the Rote Wand (see GOLLNER & ZIER, 1982, 1985) (N 47°21'46" / E 15°25'28").

**Reference section(s):** Tiefenbachgraben north of Teichalm (see GOLLNER & ZIER, 1985) (N 47°22'18" / E 15°27'54").

**Derivation of name:** After an alp in the Hochlantsch region, approximately 40 km north of Graz.

**Synonyms:** Calceola-Schichten (PENECKE, 1890; H. FLÜGEL, 1975), Kalk des Mooskofel (CLAR et al., 1929).

**Lithology:** Dark grey to black often fossiliferous limestones. Lower parts of the succession consist of light grey late diagenetic dolostones. At Tyrnaueralm and Hochlantsch a less than a half meter thick horizon of dark green porphyritic volcanites is characteristic.

**Fossils:** At Zechnerhube (Teichalm area) rugose and tabulate corals and stromatoporoids are common. For faunal list see FLÜGEL (1971).

**Origin, facies:** Parts of the successions were deposited on a tidal flat (indicated by biolaminations and fenestrate fabrics) and shallow subtidal environments (indicated by various cnidarians).

**Chronostratigraphic age:** Upper Eifelian–Givetian; not Frasnian as illustrated in the ASC 2004.

**Biostratigraphy:** *ensensis* to *varcus* conodont zones.

**Thickness:** 150 m (up to 500 m?).

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** GOLLNER & ZIER (1985) distinguished two different facial types which were considered as informal members. FLÜGEL (2000) erected the following three members:

Rote-Wand Member: Sequence of various volcanitic rocks and dolostones; 50 to 150 m in thickness.

Zechneralm Member: Interbeddings of black dolomitic *Amphipora* float/packstones and platy, sometimes laminated darkgrey dolomites; strong variation in thickness (less than 100 m).

Tiefenbach Member: Predominantly grey-blue micritic limestones, locally rich in fossils (stromatoporoids, corals); about 50 m in thickness.

**Underlying unit(s):** Plabutsch Formation (conformable contact).

**Overlying unit(s):** Zachenspitz and Hochlantsch Formations.

**Lateral unit(s):** Plabutsch Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** This formation has substantial similarities in lithology and fossil content with the Kollerkogel Formation of the Rannach Group.

**Complementary references:** HUBMANN (1993, 2003), HUBMANN & MESSNER (2007).

### Zachenspitz-Formation / Zachenspitz Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by GOLLNER & ZIER (1985: “Zachenspitzformation”); change of name into Zachenspitz-Formation by FLÜGEL (2000: p. 34).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** At the Zachenspitz, a mountain east of the Hochlantsch (see GOLLNER & ZIER, 1982, 1985) (N 47°22'05" / E 15°27'06").

**Reference section(s):** Tiefenbachgraben north of Teichalm (see GOLLNER & ZIER, 1985) (N 47°22'18" / E 15°27'54").

**Derivation of name:** After a mountain top next to Hochlantsch, approximately 40 km north of Graz.

**Synonyms:** Quadrigemminum-Kalk (PENECKE, 1890); partly: Stringocephalenschichten (HERITSCH, 1906); auffallendes Kalkband des Wallhüttenprofils (HERITSCH, 1917c).

**Lithology:** Massive and bedded grey-blue often fossiliferous limestones.

**Fossils:** Rugose and tabulate corals, stromatoporoids, conodonts, tentaculitids.

**Origin, facies:** Differentiated depositional environment composed of restricted lagoonal areas, reefal systems and open marine shallow subtidal settings.

**Chronostratigraphic age:** Upper Givetian–(?)Frasnian

**Biostratigraphy:** *varcus* conodont zone.

**Thickness:** Variable; 80 m up to 300 m.

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** GOLLNER & ZIER (1985) distinguished two different facial types which were considered as informal members. FLÜGEL (2000) erected the following two members:

Ranerwand Member: Sequence of grey flaserlimestones; subordinate argillaceous shales and volcanoclastic rocks; up to 80 m in thickness.

Teichalm Member: Grey-blue to dark-grey sometimes densely fossiliferous limestones; subordinate tuff horizons; strong variation in thickness (up to 300 m?).

**Underlying unit(s):** Tyrnaueralm Formation (conformable contact).

**Overlying unit(s):** Hochlantsch Formation and Steinberg Formation.

**Lateral unit(s):** Hochlantsch Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** This formation is characterized by the occasional occurrences of big colonial rugose *Argutastrea* corals (LIAO & HUBMANN, 2006).

**Complementary references:** HUBMANN & MESSNER (2007).

### Fahrneck-Formation / Fahrneck Formation

BERNHARD HUBMANN

**Validity:** Valid; first description and formalization by EBNER (1998: p. 128–129).

**Type area:** ÖK50-UTM, map sheet 4222 Leoben (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** Due to bad outcrops no type section published so far; according to EBNER (1998) outcrops are in the area around the farmstead “Reicherhöhe” (at altitude 999 m) north of Übelbach (30 km northwest of Graz) on ÖK50-UTM, map sheet 4222 Leoben (ÖK50-BMN, map sheet 163 Voitsberg) (N 47°25'34" / E 15°26'45").

**Reference section(s):** See above.

**Derivation of name:** After Fahrneck near Übelbach, approximately 40 km northwest of Graz.

**Synonyms:** Kalkschiefer im allgemeinen (WAAGEN, 1937).

**Lithology:** Alternating sequence of grey-blue limestones, flaser limestones, argillaceous shales and greenstones.

**Fossils:** Conodonts.

**Origin, facies:** Open marine environment?

**Chronostratigraphic age:** Frasnian–Famennian.

**Biostratigraphy:** Conodonts indicate do I and do II (= *Manticoceras* and *Cheiloceras* ammonite zones) according to TSCHLAUT (1985).

**Thickness:** About 60–80 m.

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Rotmüller Formation.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** TSCHLAUT (1985) supposed an affiliation of this succession to the Hochlantsch Nappe due to the existence of Middle to Upper Devonian volcanoclastic sediments within the formation.

**Complementary references:** FLÜGEL (2000).

### Hochlantsch-Formation / Hochlantsch Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by CLAR (1874: “Hochlantschkalk” Sic! typological error); formalized by FLÜGEL (2000: p. 35; Hochlantschkalk-Formation); change of name into Hochlantsch-Formation by EBNER et al. (2001).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** At the Hochlantsch, a mountain 40 km north of Graz (N 47°21'46" / E 15°25'28").

**Reference section(s):** -

**Derivation of name:** After Hochlantsch (1,720 m), a mountain approximately 40 km north of Graz.

**Synonyms:** Hochlantsch-Kalk (H. FLÜGEL, 1975); Hochlantschkalk (FLÜGEL & NEUBAUER, 1984); partly: Quadrigemminum-Kalk (PENECKE, 1890); Stringocephalenschichten (HERITSCH, 1906).

**Lithology:** Massive and bedded grey-blue limestones with rare fossils.

**Fossils:** Rugose and tabulate corals, stromatoporoids, conodonts.

**Origin, facies:** Lagoonal environment with some patch reefs.

**Chronostratigraphic age:** Givetian–Frasnian (? lower Famennian)

**Biostratigraphy:** Conodonts indicate upper Givetian to “do I and do II/III” (= *Manticoceras* and *Cheiloceras/Platyclymenia* ammonoid zones) according to GOLLNER & ZIER (1985: p. 52).

**Thickness:** Variable in thickness; up to 800 m.

**Lithostratigraphically higher rank unit:** Lantsch Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Tyrnaueralm Formation.

**Overlying unit(s):** Steinberg Formation.

**Lateral unit(s):** Tyrnaueralm Formation, Zachenspitze Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** HUBMANN & MESSNER (2007).

### Steinberg-Formation / Steinberg Formation

BERNHARD HUBMANN

**Validity:** Valid; first entry by ROLLE (1856: “Steinberger Kalke”); formalized by FLÜGEL (2000: p. 28) as Steinbergkalk-Formation; change of name into Steinberg-Formation by EBNER et al. (2000).

**Type area:** ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** At the type region at Forstkogel north of village Steinberg, 15 km west of Graz (ÖK50-BMN, map sheet 163 Voitsberg) (N 47°04'14" / E 15°19'28"), FLÜGEL & ZIEGLER (1957) described a section on the southern slope of Forstkogel. BUCHROITHNER et al. (1979) studied five sections in that area, but due to bad outcrop situation and the fact of “considerable fluctuation of zone thickness”, they considered a type profile inappropriate.

**Reference section(s):** BUCHROITHNER et al. (1979) mentioned five sections at Forstkogel; further reference sections are west of Gratwein 17 km northwest of Graz at Weihermühle (N 47°07'51" / E 15°18'22") and Gratwein-Au (N 47°08'31" / E 15°19'13") (EBNER, 1980).

**Remarks:** Some sections in eastern parts of the Rannach Nappe feature stratigraphic gaps especially in their upper parts (BUCHROITHNER et al., 1979; EBNER, 1980; EBNER et al., 1980a, b).

**Derivation of name:** After the village Steinberg, 15 km west of Graz.

**Synonyms:** Steinbergkalk (H. FLÜGEL, 1975; BUCHROITHNER et al., 1979; EBNER, 1980; EBNER et al., 1980a, b; FLÜGEL & NEUBAUER, 1984); partly: Clymenienkalk (PETERS,

1867; VACEK, 1907); Kramenzelkalk (HERITSCH, 1917b), Manticoceraskalk (HERITSCH, 1927c), Kalkschiefer der Rannachwiese (CLAR, 1933), Oberdevonische Flaserkalke (KUNTSCHNIG, 1937), Bunte Flaserkalke (SCHÄFER, 1937), oberer Clymenienkalk (WAAGEN, 1937).

**Lithology:** Monotonous, well-bedded flaser limestones of variable colors.

**Fossils:** Conodonts and rare macrofossils (goniatites and clymeniids; solitary rugose corals).

**Origin, facies:** Depositions of a deeper shelf margin.

**Chronostratigraphic age:** Frasnian–Famennian (also may contain uppermost Givetian).

**Biostratigraphy:** *asymmetricus* to *praesulcata* conodont zones.

**Thickness:** Approximately 70 m.

**Lithostratigraphically higher rank unit:** Rannach Group.

**Lithostratigraphic subdivision:** FLÜGEL (2000) affiliates the “Flaserkalke des Höllerer-Kogel” of EBNER et al. (1979, 1980a) as a member to the Steinberg Formation. The Höllerkogel member comprises 20 to 30 m thick thin-bedded, yellow micritic flaser limestones that are developed at the base of the formation.

**Underlying unit(s):** Kollerkogel Formation, Hochlantsch Formation (conformable contact).

**Overlying unit(s):** Sanzenkogel Formation.

**Lateral unit(s):** Hochlantsch Formation.

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 134 Passail, 163 Voitsberg, and 164 Graz.

**Remarks:** -

**Complementary references:** EBNER (1978a), SURENIAN (1978), EBNER & HUBMANN (2012).

### Sanzenkogel-Formation / Sanzenkogel Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by NÖSSING (1975: Sanzenkogel-Schichten); formalized by FLÜGEL (2000: p. 29; Sanzenkogel-Formation).

**Type area:** ÖK50-UTM, map sheet 4228 Voitsberg (ÖK50-BMN, map sheet 163 Voitsberg).

**Type section:** At Sanzenkogel west of village Steinberg, 15 km west of Graz (ÖK50-BMN, map sheet 163 Voitsberg) (N 47°04'07" / E 15°19'18"); the type section is now within the abandoned quarry “Trolp” (NÖSSING, 1975).

**Reference section(s):** Eichkogel at Rein (NÖSSING et al., 1977) (N 47°07'17" / E 15°16'22") and section “Hartbauer” (N 47°07'22" / E 15°21'58") southeast of Gratkorn (EBNER et al., 1980b).

**Derivation of name:** After the hill Sanzenkogel 15 km west of Graz.

**Synonyms:** Partly: Clymenienkalk (PETERS, 1867; VACEK, 1907); Kramenzelkalk (HERITSCH, 1917b); Manticoceraskalk (HERITSCH, 1927c); Kalkschiefer der Rannachwiese (CLAR, 1933); Oberdevonische Flaserkalke (KUNTSCHNIG, 1937); Bunte Flaserkalke (SCHÄFER, 1937); oberer Clymenienkalk (WAAGEN, 1937); *Gnathodus*-Kalk (FLÜGEL & ZIEGLER, 1957); Steinberg-Kalk (H. FLÜGEL, 1975).

**Lithology:** Monotonous, well-bedded flaser limestones of variable colors, mostly greyish; lydites.

**Fossils:** Conodonts.

**Origin, facies:** Depositions of a deeper shelf margin.

**Chronostratigraphic age:** Tournaisian–Serpukhovian.

**Biostratigraphy:** *sulcata* to *bilineatus bollandensis* conodont zones.

**Thickness:** Up to 35 m.

**Lithostratigraphically higher rank unit:** Forstkogel Group.

**Lithostratigraphic subdivision:** Within the Sanzenkogel Formation FLÜGEL (2000) distinguished two beds, Hart Bed and Trolp Bed.

Hart Bed: Well-bedded grey-yellowish lydites; variable in thickness (half a meter to 2 meters).

Trolp Bed: Dark grey marly limestones with phosphoritic nodules (diameters up to 5 cm); about 20 cm in thickness.

**Underlying unit(s):** Steinberg Formation.

**Overlying unit(s):** Höchkogel Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheets 163 Voitsberg, 164 Graz.

**Remarks:** Distinguishing lithological features between rocks of the Sanzenkogel Formation and the underlying Steinberg Formation are rather meagre. Furthermore, the subdivision of a “lower Sanzenkogel Formation” with its type section at Sanzenkogel (abandoned quarry “Trolp”; see NÖSSING, 1975) and the “upper Sanzenkogel Formation” (FLÜGEL, 2000) with its type section at the roadcut “Hartbauer” (see EBNER, 1978a) is only a biostratigraphic not a lithostratigraphic one.

**Complementary references:** BOŠIČ (1998), EBNER & HUBMANN (2012).

### Dornerkogel-Formation / Dornerkogel Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by SY (1957: “Sandsteine des Dorner-Kogels”); formalization by FLÜGEL (2000: p. 13; Dornerkogel-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined, but FLÜGEL (2000) proposed a type region at Dornerkogel, a mountain near St. Erhard (Breitenau), ÖK50-BMN, map sheet 134 Passail (N 47°21'11" / E 15°22'58").

**Reference section(s):** -

**Derivation of name:** After the mountain Dornerkogel (1,336 m) north St. Erhard (Breitenau), approx. 60 km north of Graz.

**Synonyms:** Sandsteine des Dorner-Kogels (SY, 1957); Dornerkogel-Folge (H. FLÜGEL, 1975); Dornerkogelfolge (FLÜGEL & NEUBAUER, 1984); partly: Karbon der Breitenau (FLÜGEL, 1953a).

**Lithology:** Greenish-grey arkoses, greywackes and sandstones.

**Fossils:** Undeterminable fragmental plant remains.

**Origin, facies:** Shallow marine environment.

**Chronostratigraphic age:** Carboniferous (?)

Remarks: The age of the formation is unknown but due to the presence of undeterminable fragmental plant remains a Carboniferous age is proposed (HASENHÜTTL, 1994).

**Biostratigraphy:** -

**Thickness:** Probably several hundreds of meters.

**Lithostratigraphically higher rank unit:** Laufnitzdorf Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Tectonic boundary to the Schattleitner Member (St. Jakob Formation).

**Overlying unit(s):** ?

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** -

### Bärenschütz-Formation / Bärenschütz Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by ZIER (1981: "Karbonkalke", "Mixnitzer Karbon"); formalized by FLÜGEL (2000: p. 37; Bärenschütz-Formation).

**Type area:** ÖK50-UTM, map sheet 4223 Weiz (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section selected, although ZIER (1981) described four sections in the area of the Rote Wand (Hochlantsch region) ÖK50-BMN, map sheet 134 Passail (N 47°21'54" / E 15°25'47").

**Reference section(s):** See above.

**Derivation of name:** After "Bärenschützklamm", a gorge west of Mixnitz, approx. 45 km north of Graz.

**Synonyms:** Partly Hochlantschkalk [sic!] (CLAR, 1874), Hochlantsch-Kalk (H. FLÜGEL, 1975).

**Lithology:** Reddish to yellow and grey cephalopod limestones with cherts.

**Fossils:** Conodonts, cephalopods.

**Origin, facies:** Open marine environment with pelagic organisms.

**Chronostratigraphic age:** Tournaisian–Serpukhovian ("Namurian B"); not Moskovian as indicated in the ASC 2004.

**Biostratigraphy:** *declinognathodus noduliferus* conodont zone.

**Thickness:** About 100 m.

**Lithostratigraphically higher rank unit:** Mixnitz Group (FLÜGEL, 2000).

**Lithostratigraphic subdivision:** At the base of the Bärenschütz Formation red-brown brecciated limestones and dolostones are developed following an erosional relief. This breccia horizon is integrated into the Nadelspitz Bed (FLÜGEL, 2000).

**Underlying unit(s):** Hochlantsch Formation.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 134 Passail.

**Remarks:** -

**Complementary references:** -

### Höchkogel-Formation / Höchkogel Formation

BERNHARD HUBMANN

**Validity:** Valid; first nomination and description by CLAR (1933: "Kalkschiefer vom Höchkogel"); formalized and re-described by FLÜGEL (2000: p. 30–31; Höchkogel-Formation).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) proposed a type region at Höchkogel near Gratkorn (elevation spot 643 m on ÖK50-BMN, map sheet 164 Graz) (N 47°09'22" / E 15°22'36") 16 km northwest of Graz.

**Reference section(s):** -

Remarks: CLAR's (1933) conception of the "Kalkschiefer vom Höchkogel" integrated different stratigraphic units (see FLÜGEL, 2000) and therefore the term was re-interpreted by FLÜGEL (2000). EBNER (1978a) summarized those units following the Steinberg and Sanzenkogel Formations to the "Folge der Dult" which he subdivided into two lithologically different parts. Limestones of the lower part which are developed upon an erosional surface (i.e., "Kalke der Dult" sensu EBNER, 1978a = Höchkogel Formation) are overlain by shales (i.e., "Schiefer der Dult" sensu EBNER, 1978a = Hahngraben Formation).

**Derivation of name:** After the hill Höchkogel 16 km northwest of Graz.

**Synonyms:** Kalke der Dult (EBNER, 1978a); partly: Kalke mit *Cladochonus* (HERITSCH, 1930b); Kalkschiefer vom Höchkogel (CLAR, 1933).

**Lithology:** Dark grey-brownish to black micritic limestones.

**Fossils:** Conodonts

**Origin, facies:** Shallow marine deposits.

**Chronostratigraphic age:** Bashkirian.

**Biostratigraphy:** Conodonts of the *Declinognathodus-Idiognathoides* group indicate an early Bashkirian age (EBNER, 1977, 1980a).

**Thickness:** Up to 20 m in thickness.

**Lithostratigraphically higher rank unit:** Dult Group.

**Lithostratigraphic subdivision:** FLÜGEL (2000) distinguished two members:

Hartbauer Member (= Typ II-Kalk, EBNER, 1975a = Basis-kalk, EBNER 1978a): Black massive limestones with crusts of hematite; locally dolostones, breccias and shales; maximum thickness of 20 m.

Schrausbauer Member (= Typ III-Kalk, EBNER, 1975a): Black argillaceous shales and oolitic limestones with birdseye-structures; some few meters in thickness.

**Underlying unit(s):** Sanzenkogel Formation (erosional contact).

**Overlying unit(s):** Hahngraben Formation.

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 164 Graz.

**Remarks:** -

**Complementary references:** EBNER (1976), EBNER & HUBMANN (2012).

### Hahngraben-Formation / Hahngraben Formation

BERNHARD HUBMANN

**Validity:** Valid; first description by HERITSCH (1907: "Culmschiefer"); formalized by FLÜGEL (2000: p. 31–32; Hahngraben-Formation).

**Type area:** ÖK50-UTM, map sheet 4229 Graz (ÖK50-BMN, map sheet 164 Graz).

**Type section:** No type section defined, but FLÜGEL (2000) proposed a type region at Hahngraben, a trench SE of Gratkorn (east of "Alpengarten" on ÖK50-BMN, map sheet 164 Graz) (N 47°08'45" / E 15°22'44") approx. 15 km northwest of Graz.

**Reference section(s):** -

**Derivation of name:** After the valley Hahngraben north of Dult, approx. 15 km northwest of Graz.

**Synonyms:** Culmschiefer (HERITSCH, 1907); Tonschiefergruppe (CLAR, 1933); Dultschiefer (EBNER, 1975a); Schichten der Dult (H. FLÜGEL, 1975; EBNER, 1978a).

**Lithology:** Black to grey-green argillaceous shales sometimes intercalated by silt- to sandstones with reworked lydites.

**Fossils:** Very rare plant remains of very bad preservation.

**Origin, facies:** Presumably a slightly deeper marine depositional environment; ?distal turbidites.

**Chronostratigraphic age:** Age is unknown due to the lack of age diagnostic fossils. However, an upper Bashkirian or even younger age is possible (EBNER & HUBMANN, 2012).

**Biostratigraphy:** -

**Thickness:** More than 50 m.

**Lithostratigraphically higher rank unit:** Dult Group.

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Höchkogel Formation.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Styria, highland in the surroundings of Graz; ÖK50-BMN, map sheet 164 Graz.

**Remarks:** CLAR (1933) assumed a Silurian age of the succession because of its lithologic characteristics (mica-rich shales and lydites) albeit HERITSCH (1930b) described a single specimen of "*Calamites* sp. ex gr. *C. goepperti*" (which is lost!).

**Complementary references:** EBNER (1976, 1998), EBNER et al. (2000).

## Remschnigg/Sausal / Remschnigg and Sausal areas

The underground of the Neogene basins in Western and Eastern Styria and South Burgenland is visible on some isolated swells. Most prominent are the Sausal region, the Remschnigg-Poßruck at the Styrian border to Slovenia, some isolated outcrops at the Austrian-Hungarian-Slovenian border triangle in the vicinity of St. Anna am Aigen and Rotterberg/Stadelberg and the isolated hills of Kohfidisch, Hannersdorf and Kirchfidisch (GROSS et al., 2007).

The uplift at the Sausal area and Remschnigg is linked to the "Middle Styrian Swell" [Mittelsteirische Schwelle].

Information is generally very limited since outcrops are isolated and tectonically cut and internally intensively fractured and folded; complete sequences are unknown. The monotonous, fossil-poor rocks suffered at least from green schist metamorphism thus hampering a comparison with successions of the Graz Paleozoic.

In the Sausal area acidic volcanites are interpreted as Late Ordovician in analogy to the Greywacke Zone. Sandy to clayey slates with occasionally interbedded green schists and diabases (carbonate rocks are very subordinate) probably may have a Silurian to Devonian age. At Burgstall-Grillkogel flaserlimestones and crinoidal limestones of Lochkovian to Pragian age are tectonically overlying (SCHLAMBERGER, 1987).

In the Remschnigg and Poßruck areas at the Austrian border to Slovenia, although extremely badly outcropping, a lithologically very variable sequence (not shown in the ASC 2004) is known (WINKLER-HERMADEN, 1933). Similarities in the stratigraphic sequence and tectonic development resemble the situation in the Gurktal Nappe System

(EBNER, 1987). Phyllites and diabases occur in a lower tectonic unit, which may be compared with the Murau Nappe. In the higher nappe ("Stolzalpe Nappe") the sequence includes mafic volcanoclastics (greenschists, diabases, violet tuffs), argillaceous schists, crinoidal limestones containing brachiopods and tabulate corals (HERITSCH, 1933b) and flaser limestones. Conodonts of the limestones indicate Llandovery to Late Devonian ages (EBNER, 1975b).

In contrast to the Graz Paleozoic where sedimentation younger than late Carboniferous is not recorded, red sandstones and conglomerates are developed in the Remschnigg/Poßruck area which might be Permian in age. From isolated locations, which lack contacts to other rocks, quartzitic sandstones and argillaceous shales, marls and platy limestones with remains of *Cidaris* are known. The former rocks are interpreted as equivalents of the Werfen Formation (Lower Triassic); the latter are similar with sediments of the "Raibl level" (Carnian). The succeeding dolomites and cellular dolomites possibly represent the Norian "Hauptdolomit". The succession is terminated by Upper Cretaceous limestones containing rudists and marls with coccoliths (FLÜGEL & NEUBAUER, 1984).

### Saure Vulkanoklastika / Acidic Volcanoclastics

BERNHARD HUBMANN

**Validity:** Invalid; comprehensive description by SCHLAMBERGER (1987: p. 4; "Saurer Vulkanitkomplex").

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 190 Leibnitz).



**Type section:** No type section defined; SCHLAMBERGER (1987) noticed that in the region of Kitzreck and Demmerkogel (N 46°47'10" / E 15°25'47") boulders of typical rocks of the unit are widespread.

**Reference section(s):** Generally outcrops are rare in the Sausal region and therefore sections are restricted to deeply incised small valleys only. SCHLAMBERGER (1987) mentioned prominent occurrences on the ridge of the Mandelkogel-Harrachegg-Hochbrudersegg-Mitterriegel to Kogelberg.

**Derivation of name:** After the most prominent lithology of the unit.

**Synonyms:** Mandelkogelporphroid (FLÜGEL & NEUBAUER, 1984); Saurer Vulkanitkomplex (SCHLAMBERGER, 1987); Partly: hellgrüne Talkschiefer (HILBER, 1878); Sericitphyllite (LEITMEIER, 1908); Basiskomplex (BOIGK, 1939); Mallitschberg-Serie (SCHIMUNEK, 1958); Porphyroidischer Serizitschiefer (HANSELMAYER, 1961); Orthoserizitschiefer (HANSELMAYER, 1961); Mallitschberg-Gruppe (FLÜGEL, 1964); phyllitische Schiefer (SCHÖNLAUB, 1979).

**Lithology:** Various volcanic and volcanoclastic rocks. SCHLAMBERGER (1987) mentioned two main types: greenish to white densely foliated types with phenocrysts of 0.1 to 1 mm in diameter, and black to light-green quartzitic types with phenocrysts greater than 3 mm in diameter.

**Fossils:** -

**Origin, facies:** Unknown.

**Chronostratigraphic age:** Unknown; probably pre-Silurian.

**Biostratigraphy:** -

**Thickness:** Strong variations; approx. 250 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Unknown (crystalline basement?).

**Overlying unit(s):** Metapelitic Complex.

**Lateral unit(s):** Kitzreck Slates.

**Geographic distribution:** Sausal region, ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** Due to exhaustive weathering of the Paleozoic rocks and the long-lasting wine growing, a culture dating back to the Celtic epoch, only very scattered outcrops are known in that region. Lithological similarities with the Blaseneck Porphyry resulted in assumptions of an Ordovician age of the unit.

**Complementary references:** -

### Kitzecker Schiefer / Kitzreck Slates

BERNHARD HUBMANN

**Validity:** Invalid; description in SCHÖNLAUB (1979: "Mallitschberg-Kitzreck Schiefer", resp. "Mallitschberg-Kitzreck Schichten").

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 190 Leibnitz).

**Type section:** No type section defined; SCHIMUNEK (1958) mentioned in his unpublished doctoral thesis a "locus typicus" of the "Kitzreck-Serie" along the road Fresing-Kern-Kitzreck-Tischlerwirt-Kroisgraben (N 46°46'02" / E 15°26'15").

**Reference section(s):** Reference sections (see SCHIMUNEK, 1958) are on the road Fresing-Kitzreck (N 46°46'27" / E 15°27'15") and at Kroisgraben (N 46°46'14" / E 15°26'33").

**Remarks:** Already in the 1950s outcrops were rather rare; SCHIMUNEK (1958) reported only isolated boulders which cannot be found in a successional sequence.

**Derivation of name:** After Kitzreck, the highest viticulture village of Europe (564 m altitude).

**Synonyms:** Meta-Quarzkeratophyre (ANGEL, 1924); Mallitschberg-Kitzreck-Schichten (SCHÖNLAUB, 1979); partly: Mallitschberg-Serie (SCHIMUNEK, 1958); Kitzreck-Serie (SCHIMUNEK, 1958); Mallitschberg-Gruppe (FLÜGEL, 1964).

**Lithology:** Various tectonized phyllitic quartz-rich slates.

**Fossils:** Unknown.

**Origin, facies:** ?

**Chronostratigraphic age:** Ordovician?, Silurian?

**Biostratigraphy:** -

**Thickness:** Strong variations; maximum 200 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Unknown.

**Overlying unit(s):** Metapelitic Complex.

**Lateral unit(s):** Acidic Volcaniclastics.

**Geographic distribution:** Sausal and ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** -

**Complementary references:** FLÜGEL & NEUBAUER (1984).

### Metapelitischer Komplex / Metapelitic Complex

BERNHARD HUBMANN

**Validity:** Invalid; comprehensive description by SCHLAMBERGER (1987: p. 10; "Metapelitischer Komplex").

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 190 Leibnitz).

**Type section:** No type section defined; SCHLAMBERGER (1987) presents a section of the lower part of the complex (i.e., "calcareous phyllites") at the eastern slope of Demmerkogel (N 46°47'11" / E 15°26'07").

**Reference section(s):** According to SCHLAMBERGER (1987) some small outcrops are at Steinbachgraben and east of Hohegg (E 15°28'24" / N 46°46'35").

**Remarks:** Due to bad exposure and intensive tectonic overprint no continuous sequence can be traced.

**Derivation of name:** After the most prominent lithology (weakly metamorphosed fine grained sediments) of the unit.

**Synonyms:** Partly: Gleinstätterberg-Serie (SCHIMUNEK, 1958); Serizitschiefer (HANSELMAYER, 1961); basische Vulkanite und Grünschiefer (SCHÖNLAUB, 1979); Gleinstättenberg-Serie (SCHÖNLAUB, 1979).

**Lithology:** Brownish to green calcareous phyllites (colors of the rocks depend on degree of weathering), phyllites to quartzitic phyllites (without hints of volcanic influence), dark-green to black metatuffs and metatuffites and marbles.

**Fossils:** Unknown; SCHLAMBERGER (1987) reported “ghost structures” of organic debris in thin sections.

**Origin, facies:** Shallow marine deposits (?).

**Chronostratigraphic age:** ?pre-Silurian–Silurian.

**Biostratigraphy:** -

**Thickness:** Strong variations; approx. 400 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** SCHLAMBERGER (1987) mentioned four units: calcareous phyllites with maximum thickness of 250 m, phyllites (and quartzitic phyllites) at Steinriegel southeast of Kitzack with strongly fluctuating thickness, metatuffs and metatuffites with different amounts of ore mineralizations, and marbles which occur as lenses. On the eastern slope of the Demmerkogel this marble horizon reaches a thickness of 20 to 30 m.

**Underlying unit(s):** Acidic Volcaniclastics and Mallitschberg-Kitzeck Slates.

**Overlying unit(s):** Metabasaltic Complex.

**Lateral unit(s):** Acidic Volcaniclastics.

**Geographic distribution:** Sausal region, ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** -

**Complementary references:** -

#### Metabasaltischer Komplex / Metabasaltic Complex

BERNHARD HUBMANN

**Validity:** Invalid; comprehensive description by SCHLAMBERGER (1987: p. 39; “Metabasaltkomplex”).

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 190 Leibnitz).

**Type section:** No type section published; SCHLAMBERGER (1987) noticed at Wiesberg two abandoned quarries exposing rocks of the unit (N 46°47'54" / E 15°31'26").

**Reference section(s):** SCHLAMBERGER (1987) mentioned further occurrences at Demmerkogel and Grillkogel (ÖK50-BMN, map sheet 207 Arnfels) (N 46°44'52" / E 15°24'09").

**Derivation of name:** After the dominating basaltic lithology of the unit.

**Synonyms:** Metabasaltkomplex (SCHLAMBERGER, 1987); partly: Kugeldiabase (HOERNES, 1889); Diabasporphyrit (LEITMEIER, 1907, 1908); Metadiabase [im Sausalgebirge] (ANGEL, 1924); Gleinstätterberg Serie (SCHIMUNEK, 1958); Serizit-Quarz Gesteine vom Madlkogel (SCHIMUNEK, 1958).

**Lithology:** Basaltic rocks of tholeiitic composition with various secondary changes in mineralogy.

**Fossils:** -

**Origin, facies:** Geochemical data (SCHLAMBERGER, 1987) point to a continental rift position.

**Chronostratigraphic age:** Unknown; probably Lower Devonian.

**Biostratigraphy:** -

**Thickness:** Strong variation in thickness ranging from two meters up to several meters.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Metapelitic Complex.

**Overlying unit(s):** Metapsammitic Complex.

**Lateral unit(s):** ?

**Geographic distribution:** Sausal region, ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** SCHLAMBERGER (1987) distinguished three types of metabasalts, the diabase at Wiesberg (massive and hard, dark-green to black vein rock), the metabasalts of Demmerkogel (strongly tectonized, light-green to reddish rocks), and metabasalts of Grillkogel (massive blackish basalts) at the contact to Neogene covering sediments.

**Complementary references:** FLÜGEL & NEUBAUER (1984).

#### Metapsammit Komplex / Metapsammitic Complex

BERNHARD HUBMANN

**Validity:** Invalid; comprehensive description by SCHLAMBERGER (1987: p. 18; “Metapsammitkomplex”).

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 190 Leibnitz).

**Type section:** No type section defined; SCHLAMBERGER (1987) mentions thick sequences overlying the diabasites (= Metabasaltic Complex) at Wiesberg (E 15°31'26" / N 46°47'54").

**Reference section(s):** Further outcrops for reference are stratigraphically above the diabase horizon at Kreuzkogel (496 m; N 46°47'21" / E 15°30'48"), at Demmerkogel (671 m; N 46°47'10" / E 15°25'47"), north of the road from Kostnast to Grillbauer inn and in the upper part of the Wöllinggraben at the eastern slope of Nebenegg (N 46°48'13" / E 15°26'50").

**Derivation of name:** After the most prominent lithology (weakly metamorphosed rocks with grains of sand size) of the unit.

**Synonyms:** Tonschiefer (SCHÖNLAUB, 1979); partly: Gleinstätterberg Serie (SCHIMUNEK, 1958); Serizit-Quarz Gesteine vom Madlkogel (SCHIMUNEK, 1958).

**Lithology:** Typically compact fine-grained grey, brown or light-red rocks with local interbeddings of phyllites.

**Fossils:** Unknown.

**Origin, facies:** Due to the lack of fossils and sedimentary structures unknown. Heavy minerals point to a hinterland with acidic magmatic and metamorphic rocks. Shallow marine deposits (?).

**Chronostratigraphic age:** ?Lower Devonian.

**Biostratigraphy:** -

**Thickness:** Strong variations; approx. 250 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Metabasaltic Complex.

**Overlying unit(s):** Burgstall Flaser Limestones, Greywackes.

**Lateral unit(s):** Burgstall Flaser Limestones.

**Geographic distribution:** Sausal region, ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** -

**Complementary references:** -

## Burgstaller Flaserkalke / Burgstall Flaser Limestones

BERNHARD HUBMANN

**Validity:** Invalid; first mentioned by DREGER (1905), a comprehensive description by SCHLAMBERGER (1987: p. 60; "Karbonatkomplex vom Grillkogel").

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 207 Arnfels).

**Type section:** No type section defined; SCHLAMBERGER (1987) presents a section of the quarry "Grillkogel" (458 m; N 46°44'52" / E 15°24'09").

**Reference section(s):** Further occurrences of limestones are recorded from the vicinity of the village Burgstall (N 46°44'40" / E 15°24'36") especially on the southern slope of the Grillkogel.

**Derivation of name:** After the village Burgstall.

**Synonyms:** Partly: Kalke des Burgstallkogels (DREGER, 1905; SCHIMUNEK, 1958; HERITSCH, 1943); Flaser- und Crinoidenkalke des Burgstallkogels (SCHÖNLAUB, 1979).

**Lithology:** Light grey dolostones, crinoidal limestones (sometimes intercalated with black marly slates), brownish flaser limestones with colored clay lenses ("colorful limestones") and lydites.

**Fossils:** Conodonts, badly preserved tentaculites.

**Origin, facies:** Pelagic environment.

**Chronostratigraphic age:** Pragian–Emsian (up to Givetian?) (BUGGISCH et al., 1975).

**Biostratigraphy:** -

**Thickness:** Strong variation in thickness; approx. 80 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Metabasaltic Complex.

**Overlying unit(s):** Greywackes.

**Lateral unit(s):** ?Greywackes.

**Geographic distribution:** Sausal region, ?Remschnigg; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** DREGER (1905) described the finding of a *Favosites* (now lost!) within crinoidal limestones and assumed a Devonian age. Following the description of SCHLAMBERGER (1987) of the Grillkogel quarry dolostones are unconformably overlain by a sequence of crinoidal limestones, "colorful limestones" and flaser limestones. After a fault lydites unconformably terminate the section.

**Complementary references:** -

## Grauwacken / Greywackes

BERNHARD HUBMANN

**Validity:** Invalid; collective term for very bad exposed rocks above the Devonian calcareous sequence in the Sausal – Remschnigg area.

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 207 Arnfels).

**Type section:** No section cited in the literature.

**Reference section(s):** -

**Derivation of name:** After the predominant lithology of strata overlying the phyllitic successions and crinoidal limestones respectively.

**Synonyms:** Partly: Scholle von Heiligengeist (WINKLER-HERMADEN, 1933), Grauwacken (SCHÖNLAUB, 1979).

**Lithology:** Various fine-grained siliciclastic rocks including dark colored mica-rich argillaceous slates and sandstones (see FLÜGEL & NEUBAUER, 1984).

**Fossils:** Unknown.

**Origin, facies:** ?

**Chronostratigraphic age:** Devonian (?Carboniferous).

**Biostratigraphy:** -

**Thickness:** Strong variation; presumably several tens of meters.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** ?Burgstall Flaser Limestones and rocks of the Metapsammitic Complex.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** Remschnigg, ?Sausal region; ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** -

**Complementary references:** -

## Lydite / Lydites

BERNHARD HUBMANN

**Validity:** Invalid; restricted to very small occurrences in the Remschnigg area only.

**Type area:** ÖK50-UTM, map sheet 4111 Leibnitz (ÖK50-BMN, map sheet 207 Arnfels).

**Type section:** HERITSCH (1933b) and WINKLER-HERMADEN (1933) reported isolated outcrops in the western part of the Altenbachgraben (N 46°40'18" / E 15°20'54").

**Reference section(s):** WINKLER-HERMADEN (1933) described an additional occurrence at Heiligengeistklamm – Jarzkogl (N 46°37'55" / E 15°28'09").

**Remarks:** Due to bad exposure the position of the lydites is not clear. HERITSCH (1933b) mentioned some possible connections with coral-bearing crinoidal limestones of the Remschnigg area.

**Derivation of name:** After the dominant lithology (lydite = Paleozoic chert) of the unit.

**Synonyms:** Kieselschiefer und Lydite (HERITSCH, 1933b); partly: Scholle von Altenbach (WINKLER-HERMADEN, 1933).

**Lithology:** Siliceous cherts (lydites).

**Fossils:** Unknown.

**Origin, facies:** ?

**Chronostratigraphic age:** (?)Upper Devonian.

**Biostratigraphy:** -

**Thickness:** Unknown.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Unknown; crinoidal limestones? (= ?Burgstall Flaser Limestones).

**Overlying unit(s):** Greywackes (?).

**Lateral unit(s):** -

**Geographic distribution:** Remschnigg, ?Sausal region, ÖK50-BMN, map sheets 190 Leibnitz, 207 Arnfels.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1979).

### Sandsteine / Sandstones

HANS P. SCHÖNLAUB

**Validity:** Invalid.

**Type area:** See remarks.

**Type section:** -

**Reference section(s):** -

**Derivation of name:** After the dominant lithology.

**Synonyms:** -

**Lithology:** Red quartz-sandstones and dark-grey silty shales.

**Fossils:** -

**Origin, facies:** Molasse-type sedimentation.

**Chronostratigraphic age:** -

**Biostratigraphy:** -

**Thickness:** Unknown.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** See remarks.

**Overlying unit(s):** -

**Lateral unit(s):** -

**Geographic distribution:** ÖK50-UTM, sheet 4110 Eibiswald, upper part of Lieschen creek (eastern margin of ÖK50-BMN, map sheet 206 Eibiswald; red sandstones also on ÖK50-BMN, map sheet 207 Arnfels) south of Leutschach.

**Remarks:** A sequence of red sandstones has been found in the Remschnigg area of southern Styria overlying the fossiliferous Silurian to Devonian sequence attributed by EBNER (1987) to the Murau and Stolzalpen Nappes of the Gurktal Thrust Sheet. The true relationship between the basement and the cover is unclear due to tectonic overprints. The clastic sequence starts with dark-grey silty shales and red quartz-sandstones which are correlated with the Werchzirm Formation of middle Carinthia.

**Complementary references:** -

### Südburgenland / Southern Burgenland

The Paleozoic of southern Burgenland is represented by two units which are outcropping at the Hohensteinmaißberg (south of Kirchnfidisch), near Sulz, in the Punitz woods and at the Königsberg near Hannersdorf. Additionally, the sequence is documented by drill cores taken in the 1970s (EBNER, 1978b, 1988). Based on these cores "subsurface units" in Styria, which were correlated with the sections at Sulz and Hannersdorf by EBNER (1988: Fig. 4), were named "Blumauer Phyllit-Karbonat-Formation" and "Arnwiesener Gruppe" by FLÜGEL (1988).

In general, the unit is represented by small tectonic windows which were called "Schieferinseln" (HOFFMANN, 1877) within a tectonically displaced nappe almost completely covered by Neogene sediments. A total thickness is estimated with approx. 500 m (mainly phyllitic shale, limestone and dolomite). According to strong faulting, repetition of the sequence within the relatively thick shale intervals cannot be excluded. The composite section ranges from Silurian to Lower/Middle Devonian. Until now, Pridoli to Emsian is proven by microfossils (SCHÖNLAUB, 1994; SUTTNER, 2009a). Due to facies and fossil content, shallow marine, neritic conditions dominate the depositional environment.

Although the relationship and original distance of the Paleozoic deposits of southern Burgenland to that of adjacent nappes remain unclear, lithostratigraphic equivalents are suggested with neritic units of the Graz Paleozoic (FLÜGEL, 1988) and outcrops in Hungary (compare SCHÖNLAUB, 2000a: p. 35).

#### Dolomite und Schiefer des Hochsteinmaißberg und von Sulz / Dolomites and shales from the Hochsteinmaißberg and from Sulz

THOMAS J. SUTTNER

**Validity:** Informal unit; first observed by HOFFMANN (1877); detailed description is provided by POLLAK (1962) and SCHÖNLAUB (1984a, 1994).

**Type area:** ÖK50-UTM, map sheets 5220 Rechnitz, 5225 Fürstenfeld, 5226 Kohfidisch (ÖK50-BMN, map sheets 166 Fürstenfeld, 167 Güssing, 168 Eberau).

**Type section:** -

**Reference section(s):** Hohensteinmaißberg near Kirchnfidisch (Baron von Kottwitz quarry, N 47°09'01" / E 16°21'10"), Sulz (abandoned quarry, N 47°04'43" / E 16°15'57"), Punitz Woods (abandoned quarry, N 47°08'07" / E 16°21'32") compare SCHÖNLAUB (1984a, 1994); Waltersdorf 1 (drill core), Blumau 1 and 1a (drill cores), Fürstenfeld TH 1 (drill core), Litzelsdorf (drill core) compare EBNER (1988).

**Derivation of name:** After lithologic units outcropping at the Hohensteinmaißberg and near Sulz.

**Synonyms:** Phyllit-Kalkschiefer und Dolomit-Kalkkomplex (POLLAK, 1962); Hannersdorfer Komplex (SCHMIDT, 1983); Blumauer Phyllit-Karbonat-Formation (FLÜGEL, 1988) [this formation name was suggested by FLÜGEL (1988) based on drill cores Blumau 1 and 1a (EBNER, 1988)]; Blumau-Formation (SCHÖNLAUB, 1994 sensu FLÜGEL, 1988).

**Lithology:** Phyllitic shale, calcareous marl, laminated limestone, dolomitic limestone and dolostone, bedded limestone with thin interbeds of brownish silt.

**Fossils:** Brachiopods, conodonts, corals (rugose and tabulate), echinoderms, gastropods, ostracods, serpulids, sponge spicules.

**Origin, facies:** Marine, neritic unit.

**Chronostratigraphic age:** Hence the age of the dolomites from Sulz is documented by conodonts ranging from middle Silurian to Lower Devonian, a Sheinwoodian–Lochkovian age is suggested for this unit (SCHÖNLAUB, 1984a: p. 504).

**Biostratigraphy:** Additionally to the conodont assemblage from Sulz (SCHÖNLAUB, 1984a), the *eosteinhornensis*? and *woschmidti* conodont zones are documented from a short

interval of dolomite beds of the Baron von Kottwitz quarry (SUTTNER, 2009a).

**Thickness:** > 275 m.

**Lithostratigraphically higher rank unit:** Eisenberg Group (see remarks).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Unclear, due to complex tectonics.

**Overlying unit(s):** Dolomite from Hannersdorf (conformable contact).

**Lateral unit(s):** The dolomites of this unit possibly represent equivalent units of the Graz Paleozoic and are compared with the Parmasegg Formation of the Rannach Nappe (FLÜGEL, 1988).

**Geographic distribution:** Southern Burgenland, between Kirchfidisch and Güssing.

**Remarks:** The fossiliferous Paleozoic rocks exposed around the Eisenberg in southern Burgenland were discovered by HOFFMANN (1877). By that time this area was known as “Eisenburger Comitatus”. The name Eisenberg Group was introduced by BENDA (1929) who published a detailed geological map of this area. Further comprehensive work was done by POLLAK (1962), who discriminated two units within the lithological description of the Eisenberg Group: “Dolomit-Kalkkomplex” and “Phyllit-Kalkschiefer”. These units were later described as Dolomites and shales from the Hochsteinmaißberg and from Sulz and Dolomite from Hannersdorf (SCHÖNLAUB, 1984a, 1994).

**Complementary references:** TOULA (1878), SCHMIDT (1954, 1956), SCHÖNLAUB (1979, 2000a), SCHMIDT et al. (1984), SCHÖNLAUB & HEINISCH (1994), SUTTNER & LUKENEDER (2004), GROSS et al. (2007), HUBMANN & SUTTNER (2007), LUKENEDER & SUTTNER (2007), SUTTNER (2007a, 2009b).

#### **Dolomit von Hannersdorf / Dolomite from Hannersdorf** THOMAS J. SUTTNER

**Validity:** Informal unit; first observed by HOFFMANN (1877); detailed description is provided by POLLAK (1962) and SCHÖNLAUB (1994, 2000a).

**Type area:** ÖK50-UTM, map sheets 5220 Rechnitz, 5225 Fürstenfeld, 5226 Kohfidisch (ÖK50-BMN, map sheets 166 Fürstenfeld, 167 Güssing, 168 Eberau).

**Type section:** -

**Reference section(s):** Königsberg near Hannersdorf (Weinhandl Quarry, N 47°13'19" / E 16°22'52"), Punitz Woods (abandoned quarry, N 47°08'07" / E 16°21'32") compare SCHÖNLAUB (1994); Arnwiesen 1 (drill core), Waltersdorf 1 (drill core), Blumau 1 and 1a (drill cores), Fürstenfeld 1 (drill core), Walkersdorf (drill core), Neuhaus 1 (drill core), Bachselten 1 (drill core), Mischendorf 1 (drill core),

SB 01 (drill core), ZFE 17 (drill core), ZFG 1 (drill core) compare EBNER (1988) and FLÜGEL (1988: p. 26).

**Derivation of name:** After the lithological units outcropping near the village of Hannersdorf.

**Synonyms:** Kalkglimmerschiefer und Kalkstein-Einlagerungen der Kohfidischer Schieferinsel am Kienisch-Berge bei Hannersdorf und Burg (HOFFMANN, 1877); Dolomit-Kalkkomplex (POLLAK, 1962); Hannersdorfer Komplex (SCHMIDT, 1983); Arnwiesen-Gruppe [partim] (FLÜGEL, 1988).

**Lithology:** Bedded and bright massive dolomite, shale, grey and black bedded limestone.

**Fossils:** Brachiopods, conodonts, corals (rugose and branched tabulate), echinoderms, fish teeth.

**Origin, facies:** Marine limestone, neritic unit.

**Chronostratigraphic age:** Lochkovian–Eifelian; an early Devonian age for the base of this unit was inferred by SCHÖNLAUB (1994: p. 369), who correlated the so called “Unterdevon-Dolomite von Hannersdorf im Südburgenland” with dark grey dolomites of the core “Waltersdorf 1”, which are considered to be Lochkovian to Pragian. This age was suggested due to the absence of polygnathid conodonts in the small conodont assemblage obtained by EBNER (1978b). Within the conodont assemblage from the uppermost part of the sequence in Weinhandl Quarry near Hannersdorf at the Königsberg, Pa elements of *Polygnathus serotinus* were obtained, which point to a late Emsian age (compare SCHÖNLAUB, 1994: p. 369). However, the occurrence of this species is not constricted to the *serotinus* Zone, and ranges from the base of this zone into the lowermost Eifelian.

**Biostratigraphy:** *serotinus* Zone ? (compare conodont assemblage in SCHÖNLAUB, 1994).

**Thickness:** 250–300 m.

**Lithostratigraphically higher rank unit:** Eisenberg Group (see remarks at Dolomites and shales from the Hochsteinmaißberg and from Sulz).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Dolomites and shales from the Hochsteinmaißberg and from Sulz (conformable contact).

**Overlying unit(s):** -

**Lateral unit(s):** The unit is correlated with the Flösserkogel Formation (Rannach Nappe, Graz Paleozoic) and with the Bük Dolomitformation (Hungary) by FLÜGEL (1988: p. 26).

**Geographic distribution:** Southern Burgenland, area around Hannersdorf.

**Remarks:** -

**Complementary references:** TOULA (1878), BENDA (1929), SCHMIDT (1954, 1956), SCHMIDT et al. (1984), SCHÖNLAUB (1979, 1984a), SCHÖNLAUB & HEINISCH (1994), POSCH-TRÖZMÜLLER (2002), FLEISCHHANDLER (2006), GROSS et al. (2007).

## **Karnische Alpen / Carnic Alps**

### **Pre-Variscan Sequence**

The pre-Variscan units of the Carnic Alps represent peri-Gondwanan deposits of the Rheic Ocean which was closed during the Variscan orogeny. The sequence starts with phyllitic slates and volcanites at the base. Marine limestones (neritic to pelagic) and pelagic offshore clas-

tic deposits start during the Late Ordovician and persist (including minor and major stratigraphical gaps) until the early Carboniferous. Pre-Variscan sediments of the Carnic Alps (including Austrian and Italian deposits) are restricted to an area of about 110 km (W–E extension) x 15 km (N–S

extension). The complexity of the Carnic mountain chain is known since long time and drafted in several schemes resembling the tectonic and bathymetric interrelationship of the different nappes (compare STUR, 1856; GAERTNER, 1931; KREUTZER, 1992b; SCHÖNLAUB et al., 2004). Facies types and/or nappes corresponding to different time slices (e.g., SCHÖNLAUB, 1985a) are discriminated as follows:

Ordovician units are developed in four facies types: Fleons Facies, Himmelberg Facies, Uggwa Facies and Bischofalm Facies.

Among the Silurian strata the Wolayer Facies (shallow marine limestone), Plöcken Facies (shallow to moderately deep marine limestone), Findenig Facies (slope deposits) and the Bischofalm Facies (basinal clastic sediments such as black shales or lydites) are distinguished.

The spectra of Devonian deposits include the southern shallow-water facies (intertidal, back reef, reef and reef debris limestone) of the Kellerwand Nappe, the transitional or slope facies of the Cellon Nappe, the pelagic limestone facies of the Rauchkofel Nappe, the distal pelagic siliciclastic facies of the Bischofalm Nappe and the northern shallow-water facies of the Feldkogel Nappe.

During the early Carboniferous pelagic limestones and lydites, as well as flysch sediments (with regional intercalations of neritic limestone) and volcanites were deposited.

#### **Val Visdende-Formation / Val Visdende Formation**

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; the name “Val Visdende Gruppe” for units distinguished by SCHMIDT (1930) was introduced by SCHÖNLAUB (1979); a detailed description of a part of this unit, ascribed as “Val-Visdende-Schiefer”, is provided by HUBICH & LOESCHKE (1993: p. 355).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg (ÖK50-BMN, map sheet 196 Obertilliach).

**Type section:** Section between Col Quaterná and Tscharrspitze near Passo Silvella (HUBICH & LOESCHKE, 1993; Figs. 2, 3); N 46°40'16" / E 12°28'19".

**Reference section(s):** Area near Lake Obstanser (Großer Kinigat, Pfannspitze, Roßkopf, Maurerspitze, Tscharrspitze-Gatterspitze, Passo Silvella) (HUBICH & LOESCHKE, 1993).

**Derivation of name:** After the Visdende Valley in northern Italy (SCHÖNLAUB, 1979: p. 52; see also map compiled by HINDERER, 1992: Fig. 2).

**Synonyms:** Val Visdende Gruppe [partim] (SCHÖNLAUB, 1979); Comelico phyllite (HEINISCH, 1981); Val-Visdende-Schiefer (HUBICH & LOESCHKE, 1993); Val-Visdende-Schichten (HUBICH et al., 1993); Formazione della Val Visdende (DUCA, 2004).

**Lithology:** Phyllitic schists (of variable amount of quartz) alternating with quartzite beds; subordinate conglomerate horizons occur; quartzites are less well sorted, some are of volcano-clastic origin (HUBICH & LOESCHKE, 1993: p. 355; CARLONI, 1971: p. 16).

**Fossils:** -

**Origin, facies:** The quartzites of the Val Visdende Formation probably indicate a shallow marine environment (HUBICH & LOESCHKE, 1993: p. 355). Volcanic quartz grains,

plagioclase and tourmaline suggest a source area consisting of acidic volcanic and plutonic rocks.

**Chronostratigraphic age:** Middle Ordovician (?); the age assignment is supported by the stratigraphic relationship with the overlying Comelico Porphyry the age of which is certainly Ordovician. However, the stratigraphic position and age is still controversial, as this unit could also be of Carboniferous age (compare SPALLETTA & VENTURIN, 1989; HINDERER, 1991, 1992; LÄUFER et al., 1993; VENTURINI et al., 2003).

**Biostratigraphy:** -

**Thickness:** > 500 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** -

**Overlying unit(s):** Comelico Porphyry (conformable contact?); Fleons Greywacke (conformable contact?); Himmelberg Sandstone (conformable contact?); Uggwa Shale (conformable contact?); Bischofalm Quartzite (conformable contact?).

**Lateral unit(s):** Comelico Porphyry (sensu HUBICH & LOESCHKE, 1993).

**Geographic distribution:** Western Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1985a, 2000b), VAI & COCCOZZA (1986), FISCHER et al. (1996), SCHÖNLAUB & HISTON (1999, 2000), CARULLI (2006).

#### **Comelico-Porphyröid / Comelico Porphyry**

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; this unit was named “Pfannspitzstreifen” by SCHMIDT (1930); a detailed description is provided in HUBICH & LOESCHKE (1993).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg (ÖK50-BMN, map sheet 196 Obertilliach).

**Type section:** Pfannspitze (HUBICH & LOESCHKE, 1993: p. 355), N 46°40'52" / E 12°30'05".

**Reference section(s):** Area near Lake Obstanser (Kleiner Kinigat, Großer Kinigat, Eisenreichgipfel, Tscharrspitze-Gatterspitze, Passo Silvella).

**Derivation of name:** After the region Comelico in the Province of Belluno in northern Italy.

**Synonyms:** Porphyroide des Pfannspitzsattel (SCHMIDT, 1930: p. 3); Pfannspitzstreifen (SCHMIDT, 1930: p. 4); Pre-Hercynian porphyritic plateau [partim] (SASSI & ZIRPOLI, 1968); Volcano-Sedimentary Complex (VSC) [partim] (SASSI & ZIRPOLI, 1989); Comelico “porphyroids” (SASSI & SPIESS, 1993: p. 601).

**Lithology:** Porphyry with common thin interbeds of phyllitic schists. According to HEINISCH (1981) and HUBICH & LOESCHKE (1993) the Comelico Porphyry comprises pyroclastic flow deposits (ignimbrites) with a rhyodacitic to dacitic composition. It represents volcanics of the calc-alkaline types. The 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. In addition, in thin-

sections aggregates of quartz, chlorite and muscovite can be seen which are interpreted as former lapilli or relics of collapsed pumice. However, as pointed out by HEINISCH (1981) the crystal-rich Comelico Porphyry is strongly re-crystallized and thus difficult to link to a particular type.

**Fossils:** -

**Origin, facies:** The geotectonic position is difficult to assess because ignimbrites of similar composition occur in different geotectonic settings. A back-arc basin position or a position in a post-collisional extensional field of a continental crust is possible. Its origin within the latter is documented by S-type zircons (HUBICH & LOESCHKE, 1993: p. 370).

**Chronostratigraphic age:** Based on zircon crystals a late Ordovician age is suggested by HUBICH & LOESCHKE (1993: p. 366).

**Biostratigraphy:** -

**Thickness:** 670 m

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Val Visdende Formation (conformable contact?).

**Overlying unit(s):** Following HUBICH & LOESCHKE (1993: Fig. 3, p. 355) the Comelico Porphyry is succeeded by quartzites (reworked material from the Comelico Porphyry), shale, flaser limestone and lydites of Silurian age; the Wolayer Limestone does not directly follow above the Comelico Porphyry as shown in the ASC 2004.

**Lateral unit(s):** Fleons Greywacke; Val Visdende Formation (sensu HUBICH & LOESCHKE, 1993).

**Geographic distribution:** Western Carnic Alps.

**Remarks:** -

**Complementary references:** SASSI et al. (1979), HUBICH et al. (1993), SCHÖNLAUB & HISTON (1999, 2000).

### Fleons-Grauacke / Fleons Greywacke

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; first observed by FRECH (1894b), followed by descriptions of GEYER (1899: p. 100), PELLIZZER & TOMADIN (1962), CARLONI (1971: p. 17–18), SCHÖNLAUB (1985a: p. 36–38) and by a detailed study of HINDERER (1992).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach).

**Type section:** Monte Fleons-Raudenspitze (N 46°39'45" / E 12°44'05") (HINDERER, 1992: Figs. 2, 4).

**Reference section(s):** Letterspitz and near the Roßkark (HINDERER, 1992: p. 338), Tscharrspitze (HUBICH et al., 1993: Fig. 3).

**Derivation of name:** After Mount Fleons [= Raudenspitze] (HINDERER, 1992: p. 338) near the village Fleons di sopra (N 46°38'16" / E 12°44'58").

**Synonyms:** Mauthener Schichten (FRECH, 1894b); Grüne Eruptivgesteine (Diabastuffe) und bunte Schiefer (GEYER, 1899: p. 100); Diabastuffe (GEYER, 1902); Fleonsgrauwacken (PELLIZZER & TOMADIN, 1962); Formazione del Monte Fleons (CARLONI, 1971: p. 17–18); Fleons-Grauacken

(SCHÖNLAUB, 1985a: p. 36–38); Fleonsformation (HINDERER, 1988); Roßkarkonglomerat and Tscharrknollenfazies (HINDERER, 1992); Greywacke Series (HINDERER, 1992); Fleons-Formation (HINDERER, 1992); Formazione di Fleons (DUCA, 2004).

**Lithology:** Volcaniclastic sediments (quartzites, quartzitic schists, greywacke and conglomerates).

**Fossils:** Brachiopods (?), bryozoans (SCHÖNLAUB, 1985a; SCHÖNLAUB & FLAJS, 1993).

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

**Chronostratigraphic age:** Late Ordovician age (Katian) is supported by fossil bearing intercalations of Uggwa Shale at Mount Raudenspitze (SCHÖNLAUB & FLAJS, 1993: p. 236).

**Biostratigraphy:** -

**Thickness:** > 500 m.

**Lithostratigraphically higher rank unit:** Fleons Facies (informal).

**Lithostratigraphic subdivision:** "Grauwackenserie" and "Quarzitische Serie" (HINDERER, 1992).

**Underlying unit(s):** Val Visdende Formation (conformable contact?).

**Overlying unit(s):** Following SCHÖNLAUB & FLAJS (1993: p. 236, 240–241) grey-green silty shales are interbedded between the Fleons Greywacke at the base of the overlying Uggwa Limestone (conformable contact?); the Wolayer Limestone does not directly follow above the Fleons Greywacke as shown in the ASC 2004.

**Lateral unit(s):** Val Visdende Formation and Himmelberg Sandstone, respectively (SCHÖNLAUB, 1985a: p. 36; HINDERER 1992: p. 364–365).

**Geographic distribution:** Western Carnic Alps.

**Remarks:** -

**Complementary references:** SELLI (1946, 1963), SCHÖNLAUB & HISTON (1999, 2000), SCHÖNLAUB (2000b), CARULLI (2006).

### Himmelberg-Sandstein / Himmelberg Sandstone

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; first mentioned by GAERTNER (1931: p. 125); described in detail by SCHÖNLAUB (1969a: Tab. 1, p. 273, 1971a: p. 99–102).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Upper Himmelberg Alm (see remarks) west of Mount Polinik northeast of Plöckenhaus (N 46°37'40" / E 12°57'50"), Rauchkofel (N 46°36'55" / E 12°52'31") (SCHÖNLAUB, 1971a: Fig. 2).

**Derivation of name:** After Himmelberger Alm (GAERTNER, 1931: p. 125).

**Synonyms:** Himmelberger Quarzit (GAERTNER, 1931); Dolomitische Sandsteine (SCHÖNLAUB, 1969a); Wechsellagerung Echinodermatenkalke-Karbonatsandsteine (SCHÖN-

LAUB, 1969a); Siltiti, arenarie e biocalcareni (MANARA & VAI, 1970: p. 451); Himmelberger Sandstein (SCHÖNLAUB, 1971a: p. 99–100); Himmelburger Sandstein (DULLO, 1992).

**Lithology:** Massive to well-bedded greyish to greenish sandstones and arenaceous shales showing locally cross-bedding, ripples and conglomeratic intercalations. Upward these basal clastics grade into more calcareous rocks with lense-like reddish coarse-grained limestone intercalations consisting of crinozoan debris.

**Fossils:** GAERTNER (1931) reported the following fauna from the transition of the sandstones to the overlying Wolayer Limestone: *Orthis* cf. *duftonensis*, *Dalmanella notata*, *Dalmanella* cf. *hirnantensis*, *Strophomena aquila* and *Corylocrinus* sp. In addition he observed bryozoan remains.

**Origin, facies:** Marine siliciclastics (SCHÖNLAUB, 1971a).

**Chronostratigraphic age:** This unit is not well dated yet. Katian age is proposed based on the well defined age of the overlying Wolayer Limestone (FERRETTI & SCHÖNLAUB, 2001: Katian to Hirnantian).

**Biostratigraphy:** -

**Thickness:** Approx. 60 m.

**Lithostratigraphically higher rank unit:** Himmelberg Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Dark grey shales at Himmelberg Alm of unknown age (conformable contact?).

**Overlying unit(s):** Wolayer Limestone (conformable contact).

**Lateral unit(s):** Fleons Greywacke, Uggwa Shale.

**Geographic distribution:** Central Carnic Alps, Plöcken Area.

**Remarks:** The old hut known as Upper Himmelberger Alm was destroyed after World War II but the area is still used during summer as grazing ground. It is accessible either from Spielbodenalm or along a forest road from the still existing Lower Himmelberger Alm.

**Complementary references:** HERITSCH (1943), FLÜGEL (1963), SCHÖNLAUB (1980b), HERZOG (1983), SCHÖNLAUB (1985a, 1991), SCHÖNLAUB & HISTON (1999, 2000), MADER & NEUBAUER (2004).

### Uggwa-Schiefer / Uggwa Shale

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; first mentioned by STACHE (1884) when he published fossils of the Uggwa creek (N-Italy) collected by Eduard Suess; first described by GAERTNER (1931); further observed by VAI (1971) and SCHÖNLAUB (1971a, 1979, 1985a).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Herma-gor).

**Type section:** -

**Reference section(s):** Uggwa creek (VAI, 1971), N 46°36'32" / E 13°29'03"; Feistrizgraben, Nölblinggraben, (SCHÖNLAUB, 1979: p. 45, 1985a: p. 36).

**Derivation of name:** After Uggwa creek, 200 m NNE of Rifugio Fratelli Nordio close to the village of Ugovizza in Friuli-Venezia Giulia, Italy (VAI, 1971).

**Synonyms:** Strophomena-Horizont (STACHE, 1884: p. 324); Uggwaserie (GAERTNER, 1931); Schiefer des Caradoc (HABERFELNER & HERITSCH 1932b); Sandige Schiefer mit Bryozoen (SCHÖNLAUB, 1969a: Tab. 1); Siltstone and Sandstone Member of the Uqua Formation (VAI, 1971); Siltstones et grès de L'Uqua (VAI, 1971: p. 439); grünlichgraue Siltsteine der "Stillwasser-Fazies" (SCHÖNLAUB, 1971a: Fig. 2); Greygreen siltstones (SCHÖNLAUB, 1971a: p. 368); sandig-pelitische Uggwafazies (SCHÖNLAUB, 1979); Formazione di Uqua (VAI et al., 1984); Uggwa-Schiefer (SCHÖNLAUB, 1985a: p. 36, 37, 63).

**Lithology:** Greyish to greenish pelitic to arenaceous siltstones composed of quartz, feldspar, mica and other minerals. Some horizons show indistinct bedding and are more compact resembling fine-grained sandstones. Others display lamination and a lense-like texture in thin sections. Fossils are more or less decalcified.

**Fossils:** Acritarchs, brachiopods, bryozoans, cystoids, hyolithids, tentaculites, trilobites.

**Origin, facies:** Low energetic marine deposits (SCHÖNLAUB, 1971a: p. 99).

**Chronostratigraphic age:** According to the macrofossil assemblage obtained from this unit a Katian age is suggested (e.g., VAI & SPALETTA, 1980: p. 48).

**Biostratigraphy:** -

**Thickness:** 15 m to more than 50 m.

**Lithostratigraphically higher rank unit:** Uggwa Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Fleons Greywacke (conformable contact?) (SCHÖNLAUB & FLAJS, 1993).

**Overlying unit(s):** Uggwa Limestone (conformable contact).

**Lateral unit(s):** Himmelberg Sandstone, Bischofalm Quartzite.

**Geographic distribution:** Central Carnic Alps; Uggwa Valley (Italy).

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1980b), HAVLICEK et al. (1987), PRIEWALDER (1987, 1997, 2000), SCHÖNLAUB (1991, 2000b), VAI (1998), SCHÖNLAUB & HISTON (1999, 2000), HUBMANN et al. (2003), VENTURINI (2006), BRIME et al. (2008).

### Bischofalm-Quarzit / Bischofalm Quartzite

THOMAS J. SUTTNER

**Validity:** Invalid; first described as "basal quartzite" at the base of the section Oberbuchach 1 by JAEGER & SCHÖNLAUB (1980); mapped as "Bischofalm-Quarzit" around lake Zollner by SCHÖNLAUB (1981); petrographic analysis are provided by MADER & NEUBAUER (2004).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 196 Obertilliach, 198 Weissbriach).

**Type section:** -



**Reference section(s):** Section Oberbuchach 1 along the Gundersheimer Almroad, Bischofalmgraben, Collendial (SCHÖNLAUB, 1981, 1985a: p. 40, 72).

**Derivation of name:** After the locality Bischofalm in the Carnic Alps (Austria).

**Synonyms:** Basal quartzite (JAEGER & SCHÖNLAUB, 1980: p. 404); Quarzite (JAEGER & SCHÖNLAUB, 1980: Fig. 1); dünne quarzitische Lagen (SCHÖNLAUB, 1985a: p. 40).

**Lithology:** Dark grey to grey, thin quartzite beds, dolomitic sandstone (JAEGER & SCHÖNLAUB, 1980: p. 411; SCHÖNLAUB, 1981).

**Fossils:** -

**Origin, facies:** Marine siliciclastics, pelagic unit.

**Chronostratigraphic age:** Based on the above deposited graptolite-yielding shales (Lower Bischofalm Shale) which are early Silurian in age (see SCHÖNLAUB, 1979: Fig. 17 and updated version in SCHÖNLAUB, 1985a: Fig. 13), a late Ordovician to early Silurian age is proposed for this unit by JAEGER & SCHÖNLAUB (1980) and SCHÖNLAUB (1981).

**Biostratigraphy:** -

**Thickness:** Approx. 80 m.

**Lithostratigraphically higher rank unit:** Bischofalm Nappe (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Val Visdende Formation (conformable contact?).

**Overlying unit(s):** Lower Bischofalm Shale (conformable contact).

**Lateral unit(s):** Uggwa Shale, Uggwa Limestone, Plöcken Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1985a, 1991), SCHÖNLAUB & HEINISCH (1994), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003).

### Wolayer-Kalk / Wolayer Limestone

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; first observed by STACHE (1884: p. 337); better described by GAERTNER (1931), who already used the name Wolayer Kalk for this unit; later included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach).

**Type section:** Rauchkofelboden (GAERTNER, 1931: p. 136–137); N 46°36'54" / E 12°52'30"; altitude 2,153 m.

**Reference section(s):** Seekopfsockel (N 46°36'33" / E 12°51'58"), Valentintörl (SCHÖNLAUB, 1980b).

**Derivation of name:** After the Wolayer region in the central Carnic Alps (Austria).

**Synonyms:** Stufe der weissen und grauen Kalke (STACHE, 1884); Graue, massige, versteinungsleere Kalke auf der Höhe des Thörl (FRECH, 1887: p. 685); Graue massige Kalke (FRECH, 1894b: Fig. 82); massige Bank von grauem oder rötlichem, aber hell anwitterndem Kalk [partim] (GEYER,

1903); Helle, massige Bank (SPITZ, 1909); roter und weißer, hell verwitternder Krinoidenkalk [partim] (GAERTNER, 1931); Krinoidenkalk ("helle Bank") [partim] (HABERFELNER & HERITSCH, 1932b); Biocalculititi mandorlate ("Tonflaserkalk") (MANARA & VAI, 1970); Grey massive crinoid limestone (SCHÖNLAUB, 1971a: p. 369); Ashgill-Crinoiden-Calcarenit der "Bewegtwasser-Fazies" (SCHÖNLAUB, 1971a: Fig. 2); Calcare a crinoidi, bioruditic l. ("Cystoideenkalk") (SPALLETTA et al., 1982: p. 282–283); Cystoideen-Kalk (DULLO, 1992); Cystoidean Limestone (DULLO, 1992).

**Lithology:** White massive, sparry crinoidal debris limestone (KREUTZER, 1992b).

**Fossils:** Bryozoans, crinoids, conodonts, cystoids, ostracods (rare), trilobites.

**Origin, facies:** Marine limestone, neritic unit consisting of parautochthonous bioclasts derived from crinozoan mounds (DULLO, 1992).

**Chronostratigraphic age:** Upper Ordovician (Katian-Hirnantian).

**Biostratigraphy:** *ordovicicus* conodont zone (FERRETTI & SCHÖNLAUB, 2001).

**Thickness:** 10–17 m.

**Lithostratigraphically higher rank unit:** Himmelberg Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Himmelberg Sandstone (conformable contact). Following HUBICH & LOESCHKE (1993: Fig. 3; p. 355) and SCHÖNLAUB & FLAJS (1993: p. 236 and 240–241), the Comelico Porphyry or the Fleons Greywacke, respectively, are not directly overlain by the Wolayer Limestone as shown in the ASC 2004.

**Overlying unit(s):** Plöcken Formation (unconformable contact); Kok Formation (unconformable contact).

**Lateral unit(s):** Uggwa Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** HABERFELNER & HERITSCH (1932b), HERITSCH (1932), SCHÖNLAUB (1979, 1991, 1992, 2000b), SCHÖNLAUB et al. (1997, 2004), VAI (1998), SCHÖNLAUB & HISTON (2000).

### Uggwa-Kalk / Uggwa Limestone

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Invalid; already mentioned by STACHE (1884) as Knollenkalk; first described by GAERTNER (1931); further observed by VAI (1971) and SCHÖNLAUB (1971a, 1979, 1985a); later included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 199 Hermagor).

**Type section:** Cellon avalanche gully (see remarks), Beds 1–4+ after WALLISER (1964); N 46°36'32" / E 13°29'03"; altitude 1,500 m.

**Reference section(s):** Uggwa creek (VAI, 1971), N 46°33'05" / E 13°29'13"; Valentintörl, Feistrizgraben, Nölblinggraben (SCHÖNLAUB, 1985a: p. 36; DULLO, 1992).

**Derivation of name:** After Uggwa creek, 200 m NNE of Rifugio Fratelli Nordio close to the village of Ugovizza in Friuli-Venezia Giulia, Italy (VAI, 1971).

**Synonyms:** Knollenkalk (STACHE, 1884: p. 324); Tonflaserkalke (SPITZ, 1909); Ashgill (GAERTNER, 1931: p. 133); Bereich I [partim] (WALLISER, 1964: Fig. 10, Tab. 1, p. 95); Nodular Limestone Member of the Uqua Formation (VAI, 1971); Flaserkalke, Knollenkalke, Kalkknollenschiefer (SCHÖNLAUB, 1971a: p. 368); Ashgill-Tonflaserkalk der "Stillwasser-Fazies" (SCHÖNLAUB, 1971a: Fig. 2); Uggwakalk (SCHÖNLAUB, 1979: Fig. 19, p. 44); Formazione di Uqua (VAI et al., 1984); Uggwa Formation (KREUTZER, 1992b).

**Lithology:** Grey to colored flaser limestone with bioclastic debris layers (KREUTZER, 1992b).

**Fossils:** Acritarchs, brachiopods, cephalopods, chitinozoans, crinoids, foraminifers, ostracods, styliolinids, tentaculites, trilobites.

**Origin, facies:** Marine limestone, represented by allochthonous deposits of deeper marine settings that derived from the higher energetic Wolayer Limestone (FLÜGEL, 1965; SCHÖNLAUB, 1971a; DULLO, 1992).

**Chronostratigraphic age:** Upper Ordovician (Katian).

**Biostratigraphy:** *ordovicicus* conodont zone (SERPAGLI, 1967; FERRETTI & SCHÖNLAUB, 2001).

**Thickness:** 1.1 m (at Rifugio Fratelli Nordio) to 5.4 m (at Cellon).

**Lithostratigraphically higher rank unit:** Uggwa Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Uggwa Shale (conformable contact).

**Overlying unit(s):** Plöcken Formation (conformable contact).

**Lateral unit(s):** Wolayer Limestone, Bischofalm Quartzite.

**Geographic distribution:** Carnic Alps.

**Remarks:** At the section north of Rifugio Fratelli Nordio the thickness of this unit is limited to 1.1 m to some 3 m compared with the type section at Cellon (5.4 m). In addition, the overlying Plöcken Formation is badly exposed as is the overlying shale sequence. According to JAEGER et al. (1975, p. 275) and SCHÖNLAUB (1988: p. 109) a distinct lithological change takes place within bed no. 5 or slightly below. This level defines the base of the succeeding Plöcken Formation ("4+").

**Complementary references:** SCHÖNLAUB (1980b, 1991, 1992, 2000b), PRIEWALDER (1987, 1997, 2000), BAGNOLI et al. (1998), BOGOLEPOVA & SCHÖNLAUB (1998), VAI (1998), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004), VENTURINI (2006), BRIME et al. (2008).

### Plöcken-Formation / Plöcken Formation

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB,  
ANNALISA FERRETTI

**Validity:** Valid (KREUTZER, 1992b sensu WALLISER, 1964); first description by GAERTNER (1931: p. 133) followed by SCHÖNLAUB (1969a: p. 280–281) and JAEGER et al. (1975: p. 275–278); name first used by SCHÖNLAUB (1985a: p. 38).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** Cellon avalanche gully, beds 6–8 (WALLISER, 1964), beds 5–8 (SCHÖNLAUB, 1985a); N 46°36'32" / E 12°56'25"; altitude 1,500 m.

**Reference section(s):** Section Hoher Trieb south of Obere Bischofalm (SCHÖNLAUB, 1969a, 1980b: Fig. 27, p. 50); Feistrizgraben (SCHÖNLAUB, 1980b: Figs. 4, 28; p. 52).

**Derivation of name:** After the geographic name "Plöcken" in the central Carnic Alps (Austria).

**Synonyms:** Untere Schichten (GAERTNER, 1931: p. 133); Bereich I [partim] (WALLISER, 1964: Fig. 10, Tab. 1, p. 95); Mikrofazies-Schicht '2: "Schillsandstein" and Mikrofazies-Schicht '3: "Gradierte Sandsteine" (SCHÖNLAUB, 1969a); Siltstone and Sandstone (VAI, 1971).

**Lithology:** Coarse-grained indistinctly bedded impure limestones which grade into calcareous sandstone. In the lower part contorted deformation structures, slumpings, channel fillings, loosely packed matrix-supported subangular clasts of varying composition are common as is the accumulation of fossil debris.

**Fossils:** Acritarchs (PRIEWALDER, 1987), calcareous algae, bivalves, brachiopods (JAEGER et al., 1975), chitinozoans (PRIEWALDER, 1997), conodonts (WALLISER, 1964; FERRETTI & SCHÖNLAUB, 2001), crinoids, gastropods, graptolites (rare), ostracods (SCHALLREUTER, 1990), sponge spicula (FERRETTI & SCHÖNLAUB, 2001).

**Origin, facies:** Marine sediments, which according to SCHÖNLAUB (2000b) are strongly influenced by the Late Ordovician glacial event. The influence of the Hirnantian ice age on the depositional environment is characterized by channeling, erosion and local non-deposition.

**Chronostratigraphic age:** Upper Ordovician (Hirnantian).

**Biostratigraphy:** *persculptus* graptolite zone (JAEGER et al., 1975) and a mixed conodont fauna including elements of the *ordovicicus* Zone and some stratigraphically slightly younger species (FERRETTI & SCHÖNLAUB, 2001).

**Thickness:** Varies between 1.5 and 9 m; at its type section, the unit reaches 5.4 m in thickness.

**Lithostratigraphically higher rank unit:** Uggwa Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Wolayer Limestone (unconformable contact), Uggwa Limestone (conformable contact).

**Overlying unit(s):** Kok Formation (unconformable contact); Nöbling Formation (unconformable contact).

**Lateral unit(s):** Bischofalm Quartzite.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SPITZ (1909), SCHÖNLAUB (1971a, 1991), PRIEWALDER (2000), SCHÄTZ et al. (1997, 2002), VAI (1998), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004).

## Kok-Formation / Kok Formation

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB

**Validity:** Valid (KREUTZER, 1992b sensu WALLISER, 1964); name first used by SCHÖNLAUB (1985a: p. 38).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3112 Villach, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal, 3118 Arnoldstein (ÖK50-BMN, map sheets 197 Kötschach, 199 Hermagor, 200 Arnoldstein).

**Type section:** Cellon avalanche gully, beds 9–20 (WALLISER, 1964), N 46°36'32" / E 12°56'24".

**Reference section(s):** Rauchkofelboden, Kokberg, Valentintörl section.

**Derivation of name:** Kokberg [= Monte Cocco].

**Synonyms:** Untersilurische Schichten [partim] (STACHE, 1874); Rotheisenstein (SEELAND, 1878); Unterer Eisenkalk (FRECH, 1887); Grauer Netzkalk (GEYER, 1894); Thonschiefer (GEYER, 1894); Bunte Flaser- oder Bänderkalke und Kalkphyllite des Obersilur [partim] (GEYER, 1899); Unterer Orthocerenkalkniveau (GEYER, 1903); Calcare ad Orthoceras (VINASSA DE REGNY & GORTANI, 1905); Calcari reticolati con facies a Cefalopodi (GORTANI & VINASSA DE REGNY, 1909); Kokkalke (HERITSCH, 1929); Kokkalk (GAERTNER, 1931); Trilobitenschiefer (GAERTNER, 1931); Aulacopleura-schicht (GAERTNER, 1931; SCHÖNLAUB, 1985a); Krinoidenkalk ("helle Bank") [partim] (HABERFELNER & HERITSCH 1932b); Kok Limestone (SCHÖNLAUB, 1980b); Calcare ad Aulacopleura (SPALLETTA et al., 1982); Calcare del Cocco (SPALLETTA et al., 1982); Marne a trilobite (SPALLETTA et al., 1982); Crinoiden-Brachiopoden-Kalke (SCHÖNLAUB, 1985a); Aulacopleura Limestone (SPALLETTA & VENTURINI, 1989); Orthoceras Limestone (FERRETTI et al., 1999).

**Lithology:** Well bedded ferruginous grey and red limestone with blackish marly shale.

**Fossils:** Acritarchs (PRIEWALDER, 1987), bivalves (KRIZ, 1979, 1999), brachiopods (PŁODOWSKI, 1971, 1973), cephalopods (RISTEDT, 1968; BOGOLEPOVA, 1998; HISTON, 1999), chitinozoans (PRIEWALDER, 1997), conodonts (WALLISER, 1964; SCHÖNLAUB, 1979), foraminifers (LANGER, 1969), gastropods, graptolites (JAEGER, 1975), trace fossils (HISTON & SCHÖNLAUB, 1999), trilobites (HAAS, 1969; SANTEL, 1999).

**Origin, facies:** Marine limestone, neritic and pelagic units are discriminated (Plöcken Facies).

**Chronostratigraphic age:** Llandovery–Ludlow.

**Biostratigraphy:** *celloni*, *amorphognathoides*, *patula*, *sagitta*, *bohemica* and *ploeckensis* conodont zones (WALLISER, 1964); *potens* orthoceric zone (HISTON et al., 1999).

**Thickness:** Approx. 15 m (neritic unit), 4 m (pelagic unit).

**Lithostratigraphically higher rank unit:** Plöcken Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Wolayer Limestone (unconformable contact); Plöcken Formation (unconformable contact).

**Overlying unit(s):** Cardiola Formation (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** FRECH (1887), SPITZ (1909), HERITSCH (1932, 1943), FLÜGEL (1965), PÖLSLER (1967), MANARA & VAI (1970), SCHÖNLAUB (1970, 1982c, 1991, 1997), TIETZ (1976), KREUTZER (1994), SCHÖNLAUB et al. (1997, 2004), WENZEL (1997), VAI (1998, 1999), PASAVA & SCHÖNLAUB (1999), FERRETTI et al. (1999), PRIEWALDER (2000), SCHÖNLAUB & HISTON (2000), CORRADINI et al. (2003), HUBMANN et al. (2003), LOYDELL (2003), FERRETTI (2005), BRIME et al. (2008), BRETT et al. (2009).

## Nölbling-Formation / Nölbling Formation

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB

**Validity:** Valid (JAEGER & SCHÖNLAUB, 1977); first described by GEYER (1895).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** Nölblinggraben (JAEGER & SCHÖNLAUB, 1977: p. 351), N 46°38'14" / E 13°05'04".

**Reference section(s):** Gundersheimer Alm road (Oberbuchach section), Collendiaul, Dellacher Alm (JAEGER & SCHÖNLAUB, 1980; BRETT et al., 2009).

**Derivation of name:** After the Nölblinggraben near the village of Nölbling (JAEGER & SCHÖNLAUB, 1977).

**Synonyms:** Complex von Thonschiefer, Grauwacke und Kieselschiefer (GEYER, 1895); Kieselschieferkomplex (PÖLSLER, 1969a, b); Löchriger Kalk (PÖLSLER, 1969a).

**Lithology:** Blackish marly shale alternating with alau shale and dark platy limestone, siliceous shale and lydites are exposed in the lower part.

**Fossils:** Bivalves, cephalopods, conodonts, crinoids, gastropods, graptolites, trilobites, radiolarians.

**Origin, facies:** Marine limestone, pelagic unit (Pelagic Carbonate Facies).

**Chronostratigraphic age:** Llandovery–Lochkovian (?).

**Biostratigraphy:** *triangulatus-bohemicus* graptolite zone (JAEGER & SCHÖNLAUB, 1977, 1980).

**Thickness:** 40–50 m.

**Lithostratigraphically higher rank unit:** Rauchkofel Nappe (or in terms of facial development: Findenig Facies, compare SCHÖNLAUB & HISTON, 1999) (all informal units).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Plöcken Formation (unconformable contact).

**Overlying unit(s):** Findenig Limestone (conformable contact).

**Lateral unit(s):** Kok Formation; Cardiola Formation; Alticola Limestone; Megaerella Limestone; Rauchkofel Limestone; Lower Bischofalm Shale; Middle and Upper Bischofalm Shale.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** GORTANI (1925), SCHÖNLAUB (1970, 1985a, 1991, 1998), SCHÖNLAUB & DAURER (1977), RANTITSCH (1991, 1992a), SCHÖNLAUB & KREUTZER (1994a), WENZEL (1997), VAI (1998), PASAVA & SCHÖNLAUB

(1999), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004), VENTURINI (2006), HISTON et al. (2007).

### **Untere Bischofalm-Schiefer / Lower Bischofalm Shale**

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB

**Validity:** Invalid; the graptolite bearing section at the Obere Bischofalm was discovered by STACHE (1872); the section was studied in detail by JAEGER (in FLÜGEL et al., 1977) and later by SCHÖNLAUB (1985a); important biostratigraphic studies have been performed by JAEGER & SCHÖNLAUB (1980).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Area around Lake Zollner (SCHÖNLAUB, 1981), N 46°36'21" / E 13°04'17"; Obere Bischofalm (N 46°35'57" / E 13°03'11"), Feistritzgraben, Gundersheimer Alm road (Oberbuchach section), Collendiaul, Dellacher Alm, Nölblinggraben (SCHÖNLAUB, 1985a).

**Derivation of name:** After the locality Bischofalm in the Carnic Alps (Austria).

**Synonyms:** Graptoliten-Schiefer (STACHE, 1872); Lower Graptolitic Shales (FLÜGEL et al., 1977).

**Lithology:** Black alau shale and lydites, greyish green shale.

**Fossils:** Conodonts, graptolites.

**Origin, facies:** Marine siliciclastics, pelagic unit (Distal Siliciclastic Facies).

**Chronostratigraphic age:** Llandovery–Ludlow.

**Biostratigraphy:** *acuminatus–nilssoni* graptolite zones (FLÜGEL et al., 1977; JAEGER & SCHÖNLAUB, 1980).

**Thickness:** 10–20 m.

**Lithostratigraphically higher rank unit:** Bischofalm Nappe (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bischofalm Quartzite (conformable contact).

**Overlying unit(s):** Middle and Upper Bischofalm Shale (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** HABERFELNER (1931), HERITSCH (1936), SCHÖNLAUB (1969a, 1985a, 1991, 1998), RANTITSCH (1992a), JAEGER & SCHÖNLAUB (1994), VAI (1998), SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004), VENTURINI (2006), HISTON et al. (2007).

### **Cardiola-Formation / Cardiola Formation**

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB

**Validity:** Invalid; first named “Cardiola-Horizont” by STACHE (1884: p. 329); later well described by GAERTNER (1931); additional biostratigraphic and sedimentological investiga-

tions were carried out by WALLISER (1964) and SCHÖNLAUB (1985a); a summary on this unit is provided by KREUTZER (1992b) and later by BRETT et al. (2009).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld, 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 197 Kötschach, 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Cellon avalanche gully (WALLISER, 1964), N 46°36'32" / E 12°56'23"; Rauchkofel northern wall, Kellerwand, Rauchkofelboden (BRETT et al., 2009); Seeberg Aufbruch (KUPSCH et al., 1971).

**Derivation of name:** After the bivalve *Cardiola* (STACHE, 1884: p. 331).

**Synonyms:** Untersilurische Schichten [partim] (STACHE, 1874); *Cardiola*-Horizont (STACHE, 1884); Grauer Plattenkalk (FRECH, 1887); *Cardiola*-Niveau (GEYER, 1894); *Cardiola*-schichten (GEYER, 1894); Bunte Flaser- oder Bänderkalk und Kalkphyllite des Obersilur [partim] (GEYER, 1899); *Cardiolaniveau* (GAERTNER, 1931); *Cardiola*-Niveau (GAERTNER, 1931); *Cardiola* Beds (SCHÖNLAUB, 1970).

**Lithology:** Dark grey to black limestone with interbedded layers of marl and shale.

**Fossils:** Acritarchs (PRIEWALDER, 1987), bivalves (KRIZ, 1979, 1999), brachiopods (PLODOWSKI, 1971, 1973), cephalopods (RISTEDT, 1968; BOGOLEPOVA, 1998; HISTON, 1999), chitinozoans (PRIEWALDER, 1997), conodonts (WALLISER, 1964; SCHÖNLAUB, 1979), graptolites (JAEGER, 1975), radiolarians (KREUTZER, 1994), rugose corals (PICKETT, 2007), trace fossils (HISTON & SCHÖNLAUB, 1999), trilobites (HAAS, 1969).

**Origin, facies:** Marine limestone, pelagic unit (Plöcken Facies).

**Chronostratigraphic age:** Ludlow.

**Biostratigraphy:** *siluricus* conodont zone (WALLISER, 1964); *potens* orthocerid zone (HISTON et al., 1999).

**Thickness:** 0.5–4 m.

**Lithostratigraphically higher rank unit:** Plöcken Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kok Formation (conformable contact).

**Overlying unit(s):** Alticola Limestone (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps (Plöcken Area), Karavanke Mountains (Seeberg area).

**Remarks:** -

**Complementary references:** TELLER (1886b, 1887), SPITZ (1909), HERITSCH (1929), WALLISER (1957), FLÜGEL (1965), PÖLSLER (1967), RISTEDT (1969), MANARA & VAI (1970), SCHÖNLAUB (1980b, 1985a, 1991, 1997, 1998), SIEWERT (1984), SCHÖNLAUB et al. (1997, 2004), WENZEL (1997), VAI (1998, 1999), FERRETTI et al. (1999), HISTON et al. (1999), SCHÖNLAUB & HISTON (1999, 2000), PRIEWALDER (2000), CORRADINI et al. (2003).

### Alticola-Kalk / Alticola Limestone

THOMAS J. SUTTNER, HANS P. SCHÖNLAUB

**Validity:** Invalid; first described by FRECH (1887: p. 684, 701, 706) as “Zone des *Orthoceras alticola*”; well described by GAERTNER (1931); biostratigraphic and sedimentological investigations were carried out by WALLISER (1964) and SCHÖNLAUB (1985a); a summary on this unit is provided by KREUTZER (1992b) and later by BRETT et al. (2009).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal, 3118 Arnoldstein, 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor, 200 Arnoldstein, 201-210 Villach-Assling, 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Cellon avalanche gully (WALLISER, 1964), N 46°36'32" / E 12°56'23"; Rauchkofel Boden section, Valentintörl section, near Pessendellach, south of Arnoldstein, near Agoritschach, Monte Cocco II section (BRETT et al., 2009); Kokra- and Korpitschgraben, Feisritzgraben below Illitsch, Worounitzagraben, Trögern and Seeberg (KUPSCH et al., 1971).

**Derivation of name:** After the nauloid species *Orthoceras alticola* BARRANDE (FRECH, 1887).

**Synonyms:** Untersilurische Schichten [partim] (STACHE, 1874); Unterer rother Orthoceren Kalk, wechsellagernd mit grauem Kalke (FRECH, 1887: p. 684); Zone des *Orthoceras alticola* (FRECH, 1887: p. 684, 701); Bunte Flaser oder Bänderkalke und Kalkphyllite des Obersilur [partim] (GEYER, 1899); Calcari reticolati – facies a Cefalopodi (GORTANI & VINASSA DE REGNY, 1909); Orthoceren-(*alticola*-) Kalke (GAERTNER, 1931); Orthocerenkalk (HABERFELNER & HERITSCH, 1932b); Alticola Limestone (SCHÖNLAUB, 1970); Calcare ad Alticola (SPALLETTA et al., 1982); Alticola Formation (KREUTZER, 1992b).

**Lithology:** Grey to red bedded orthocerid limestone with interbedded layers of coarse fossil debris yielding brachiopod valves.

**Fossils:** Acritarchs (PRIEWALDER, 1987), bivalves (KRIZ, 1979, 1999), brachiopods (PŁODOWSKI, 1971, 1973), cephalopods (RISTEDT, 1968; BOGOLEPOVA, 1998; HISTON, 1999), chitinozoans (PRIEWALDER, 1997), conodonts (WALLISER, 1964; SCHÖNLAUB, 1979), echinoderms, foraminifers (LANGER, 1969), graptolites (JAEGER, 1975), rugose corals (PICKETT, 2007), scyphocritinids (FERRETTI et al., 1999: p. 60), trace fossils (HISTON & SCHÖNLAUB, 1999), trilobites (HAAS, 1969; SANTEL, 1999).

**Origin, facies:** Marine limestone, pelagic unit (Plöcken Facies).

**Chronostratigraphic age:** Ludlow–Pridoli.

**Biostratigraphy:** *latialatus* and *eosteinhornensis* conodont zones (WALLISER, 1964).

**Thickness:** 20 m.

**Lithostratigraphically higher rank unit:** Plöcken Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Cardiola Formation (conformable contact).

**Overlying unit(s):** Megaerella Limestone (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps, Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** GEYER (1894), SPITZ (1909), HERITSCH (1929, 1943), WALLISER (1957), FLÜGEL (1965), PÖLSLER (1967), HAAS (1969), MANARA & VAI (1970), SCHÖNLAUB (1971a, 1980b, 1982c, 1982d, 1991, 1997), TIETZ (1976), SIEWERT (1984), MOSHAMMER (1987, 1990), KREUTZER (1994), SCHÖNLAUB et al. (1997, 2004), WENZEL (1997), VAI (1998, 1999), HISTON et al. (1999), PASAVA & SCHÖNLAUB (1999), SCHÖNLAUB & HISTON (1999, 2000), PRIEWALDER (2000), BRETT et al. (2009), CORRIGA & CORRADINI (2009).

### Megaerella-Kalk / Megaerella Limestone

THOMAS J. SUTTNER, ERIKA KIDO, HANS P. SCHÖNLAUB

**Validity:** Invalid; discriminated by FRECH (1887: p. 687, 700, 714) as “Zone der *Rhynchonella Megaera*”; well described by GAERTNER (1931); biostratigraphic and sedimentologic investigations were carried out by WALLISER (1964) and SCHÖNLAUB (1980b, 1985a); a summary of this unit is provided by KREUTZER (1992b) and BRETT et al. (2009).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach (?), 199 Hermagor).

**Type section:** -

**Reference section(s):** Cellon avalanche gully (WALLISER, 1964), N 46°36'31" / E 12°56'22"; Seewarte, Valentintörl (SCHÖNLAUB, 1980b).

**Derivation of name:** After the brachiopod *Rhynchonella megaera* (FRECH, 1887: p. 687).

**Synonyms:** Zone der *Rhynchonella Megaera* (FRECH, 1887); Calcari reticolati – facies a Brachiopodi (GORTANI & VINASSA DE REGNY, 1909); *Rhynchonella megaera*-Schichten (GAERTNER, 1931); *Rh. megaera*-Schichten (WALLISER, 1957); Kalk mit *H. megaera* (PÖLSLER, 1967); Black nodular Limestones (SCHÖNLAUB, 1980b); Megaerella Beds (SCHÖNLAUB, 1980b); Strati a Megaerella (SPALLETTA et al., 1982); Megaerella Formation (KREUTZER, 1992b).

**Lithology:** Bright, greyish, bioclastic limestones (BRETT et al., 2009).

**Fossils:** Acritarchs (PRIEWALDER, 1987), bivalves (KRIZ, 1979, 1999), brachiopods (PŁODOWSKI, 1971, 1973), bryozoans, cephalopods (RISTEDT, 1968; BOGOLEPOVA, 1998; HISTON, 1999), chitinozoans (PRIEWALDER, 1997), conodonts (WALLISER, 1964; SCHÖNLAUB, 1979), echinoderms, foraminifers (LANGER, 1969), graptolites (JAEGER, 1975), scyphocritinids (SCHÖNLAUB, 1970, 1985a; HISTON et al., 1999: p. 51), trace fossils (HISTON & SCHÖNLAUB, 1999), trilobites (HAAS, 1969; SANTEL, 1999).

**Origin, facies:** Marine limestone, shallow to moderately deep shelf (Plöcken Facies).

**Chronostratigraphic age:** Pridoli.

**Biostratigraphy:** *eosteinhornensis* conodont zone.

**Thickness:** 8 m.

**Lithostratigraphically higher rank unit:** Plöcken Facies (informal).

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Alticola Limestone (conformable contact).

**Overlying unit(s):** Rauchkofel Limestone (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** FRECH (1894b), HERITSCH (1929), VAI (1963, 1998, 1999), FLÜGEL (1965), RISTEDT (1969), SCHÖNLAUB (1970, 1971a, 1985a, 1997), TIETZ (1976), KREUTZER (1994), SCHÖNLAUB & KREUTZER (1994a), WENZEL (1997), FERRETTI et al. (1999), PASAVA & SCHÖNLAUB (1999), SCHÖNLAUB & HISTON (1999, 2000), PRIEWALDER (2000), SCHÖNLAUB et al. (2004), CORRADINI et al. (2005), SUTTNER (2007b).

### **Bodenkalk / Boden Limestone**

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; lithological characters and conodont biostratigraphy provided by SCHÖNLAUB (1980b, 1985a); facies described by KREUTZER (1992a); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Rauchkofel Boden section (SCHÖNLAUB, 1985a), N 46°36'54" / E 12°52'40".

**Derivation of name:** after the Rauchkofel Boden on Mount Rauchkofel (SCHÖNLAUB, 1985a: p. 43).

**Synonyms:** *Orthoceras* Lst. (SCHÖNLAUB, 1980b).

**Lithology:** Light flaser limestone (KREUTZER, 1992b).

**Fossils:** Cephalopods (orthoconic and coiled nautiloids), conodonts, tentaculites (dacryoconarids).

**Origin, facies:** Marine limestone, following KREUTZER (1992a) this unit belongs to the Pelagic Carbonate Facies (compare Fig. 10 in SCHÖNLAUB, 1985a). Wrongly illustrated as shallow neritic unit in the ASC 2004.

**Chronostratigraphic age:** Lochkovian.

**Biostratigraphy:** *delta* and *pesavis* conodont zones (SCHÖNLAUB, 1980b).

**Thickness:** 20 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Rauchkofel Limestone (conformable contact).

**Overlying unit(s):** Findenig Limestone (conformable contact).

**Lateral unit(s):** Rauchkofel Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1991, 1992), FERRETTI et al. (1999), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004), CORRIGA & CORRADINI (2009).

### **Rauchkofel-Kalk / Rauchkofel Limestone**

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; known since FRECH (1887); two different facies of limestone are discriminated, i.e., neritic Rauchkofel Limestone and pelagic Rauchkofel Limestone (SCHÖNLAUB, 1980b: Fig. 3; SCHÖNLAUB, 1985a: Fig. 10); a detailed study on the facies of the neritic unit at Mount Seewarte has been done by BANDEL (1969), POHLER (1982) and additional conodont-biostratigraphy by SUTTNER (2007b); the pelagic unit was well described by SCHÖNLAUB (1985a: p. 42–43); a summary of lithostratigraphic characters of this formation is provided by KREUTZER (1992b: p. 25–26).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3112 Villach, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal, 3118 Arnoldstein (ÖK50-BMN, map sheets 197 Kötschach, 198 Weissbriach, 199 Hermagor, 200 Arnoldstein).

**Type section:** -

**Reference section(s):** Section at the footwall of Mount Seewarte (BANDEL, 1969; neritic Rauchkofel Limestone), N 46°36'40" / E 12°52'24"; Rauchkofel South section (SCHÖNLAUB, 1985a; pelagic Rauchkofel Limestone).

**Derivation of name:** After Mount Rauchkofel.

**Synonyms:** Korallenriffkalk am Wolayer- u. Seekopf-Thörl [partim] (FRECH, 1887: p. 700); unterdevonischer Riffkalk [partim] (FRECH, 1894b: p. 229); Schwarze Plattenkalke (GAERTNER, 1931); ey-Plattenkalke (GAERTNER, 1931); ey-Schichten (GAERTNER, 1931); Schwarze Kalke der Einheiten 0b, 0d, 0f, 0g (BANDEL, 1969); ey limestone (SCHÖNLAUB, 1980b: Fig. 3); Conjugula Lst. (SCHÖNLAUB, 1980b: Fig. 3); Neritic Rauchkofel Limestone (KREUTZER, 1992b sensu SCHÖNLAUB, 1985a); Pelagic Rauchkofel Limestone (KREUTZER, 1992b sensu SCHÖNLAUB, 1985a); Rauchkofel Formation (SUTTNER, 2007b; informal).

**Lithology:** Dark, platy limestone, lithoclastic limestone, dark nodular limestone, mega-conglomerate horizon (only neritic unit), well bedded dark grey crinoidal limestone.

**Fossils:** Acritarchs, brachiopods, chitinozoans, conodonts, crinoids, gastropods.

**Origin, facies:** Marine limestone, neritic and pelagic units are discriminated (Southern shallow-water Facies and Transitional to Pelagic Carbonate Facies).

**Chronostratigraphic age:** Lochkovian–Pragian.

**Biostratigraphy:** *?woschmidti*, *delta*, *pesavis* and *steinachensis* conodont zones (conodont zones within the neritic unit at Mount Seewarte; SUTTNER, 2007b); *woschmidti* Zone (conodont zone within the pelagic unit of the Rauchkofel Boden section; SCHÖNLAUB, 1980b: p. 39).

**Thickness:** About 180 m (neritic unit), 80–120 m (pelagic unit).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** Divided into neritic and pelagic Rauchkofel Limestone (compare Fig. 10 in SCHÖNLAUB, 1985a); the neritic unit at Mount Seewarte was subdivided into "Einheit 0a-0g" by BANDEL (1969).

**Underlying unit(s):** Megaerella Limestone (conformable contact), Nölbling Formation (conformable contact).

**Overlying unit(s):** Gamskofel Limestone (conformable contact), Hohe Warte Limestone (conformable contact), Kellerwand Limestone (conformable contact), Boden Limestone (conformable contact).

**Lateral unit(s):** Boden Limestone, Nölbling Formation.

**Geographic distribution:** Carnic Alps, Karavanke Mountains.

**Remarks:** -

**Complementary references:** PALLA (1965, 1966, 1967), (PÖLSLER, 1967), KODSI (1971), SCHÖNLAUB (1971-1973, 1984b, 1991, 1992), PRIEWALDER (1987, 1997, 2000), KREUTZER (1990, 1992a), FENNINGER & HUBMANN (1994), HUBMANN (1994), KREUTZER et al. (1997, 2000), SCHÖNLAUB & KREUTZER (1997), VAI (1998), FERRETTI et al. (1999), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004), SUTTNER (2005), CARULLI (2006), VENTURINI (2006), HUBMANN & SUTTNER (2007), BRIME et al. (2008), CORRIGA & CORRADINI (2009), SUTTNER & KIDO (2011).

#### Mittlere und Obere Bischofalm-Schiefer / Middle and Upper Bischofalm Shales

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; the graptolite bearing section at the Obere Bischofalm was discovered by STACHE (1872); the section was studied in detail by JAEGER (in FLÜGEL et al., 1977) and later by SCHÖNLAUB (1985a); an important biostratigraphic study has been performed by JAEGER & SCHÖNLAUB (1980).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spital an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Area around Lake Zollner (SCHÖNLAUB, 1981), N 46°36'21" / E 13°04'17"; Obere Bischofalm (Graptolithengraben), Gundersheim Alm road (Oberbuchach section), Collendiaul, Dellach Alm, Nöblinggraben (SCHÖNLAUB, 1985a).

**Derivation of name:** After the Bischofalmgraben (SCHÖNLAUB, 1985a: Fig. 14, p. 40, 72).

**Synonyms:** Graptoliten-Schiefer (STACHE, 1872); Grey-green eß-shales (FLÜGEL et al., 1977: syn. Middle Bischofalm Shale); Upper Graptolitic Shales (FLÜGEL et al., 1977).

**Lithology:** Black alau shale and lydites, greyish green shale.

**Fossils:** Graptolites.

**Origin, facies:** Marine, pelagic unit (Distal Siliciclastic Facies).

**Chronostratigraphic age:** Ludlow to Pridoli (M. B. Shale); Pridoli to Lochkovian (U. B. Shale).

**Biostratigraphy:** M. B. Shale: *bohemicus-transgrediens* graptolite zones (FLÜGEL et al., 1977; JAEGER & SCHÖNLAUB, 1980); U. B. Shale: *transgrediens, uniformis, praehercynicus* and *hercynicus* graptolite zones (FLÜGEL et al., 1977; JAEGER & SCHÖNLAUB, 1980).

**Thickness:** 4–5 m (Middle Bischofalm Shale) and 10 m (Upper Bischofalm Shale).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Bischofalm Shale (conformable contact).

**Overlying unit(s):** Findenig Limestone (conformable contact), Zollner Formation (conformable contact).

**Lateral unit(s):** Nölbling Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** HABERFELNER (1931), FLÜGEL (1953b), SCHÖNLAUB (1969a, 1971a, 1985a, 1991, 1998), JAEGER & SCHÖNLAUB (1994), VAI (1998), SCHÖNLAUB & HISTON (1999, 2000), SCHÖNLAUB et al. (2004), VENTURINI (2006), HISTON et al. (2007).

#### Gamskofel-Kalk / Gamskofel Limestone (note the typological error "Gamskogel-Kalk" in the ASC 2004)

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; some of the sections at Mount Gamskofel were already measured by BANDEL (1972); facies of the Gamskofel Limestone was observed by SCHÖNLAUB (1985a: p. 43); well described by KREUTZER (1990, 1992a); later included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b: p. 26–27).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Section on the northern side of the Gamskofel at the Bösen Gangele between Raimunda Törl and Wodner Törl (KREUTZER, 1992b: p. 27), N 46°38'01" / E 12°54'06".

**Derivation of name:** After Mount Gamskofel (KREUTZER, 1992a).

**Synonyms:** -

**Lithology:** Algal laminite with *Amphipora* limestone and loferite layers.

**Fossils:** Calcareous algae, brachiopods, corals, foraminifers, ostracods.

**Origin, facies:** Marine limestone, intertidal (KREUTZER, 1990: p. 306), neritic unit; Southern Shallow-water Facies (KREUTZER, 1992a).

**Chronostratigraphic age:** Pragian–Givetian(?).

**Biostratigraphy:** -

**Thickness:** Approx. 800 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Rauchkofel Limestone (conformable contact).

**Overlying unit(s):** Feldkogel Formation (conformable contact), Plotta Lydite (unconformable contact).

**Lateral unit(s):** Hohe Warte Limestone, Seewarte Limestone, Lambertenghi Limestone, Spinotti Limestone, Kellergrat Reef Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004).

### Hohe Warte-Kalk / Hohe Warte Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; lithologically well described by BANDEL (1969); additional stratigraphy and facies analysis by VAI (1973), SCHÖNLAUB & FLAJS (1975), SCHÖNLAUB (1980b) and POHLER (1982); summary on this unit is provided by KREUTZER (1990, 1992b: p. 27); detailed biostratigraphy is given by SUTTNER (2007b), who used the name Hohe Warte Formation for this unit.

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach).

**Type section:** -

**Reference section(s):** Section along the lower part of the Koban-Prunner route at the northern wall of Mount Hohe Warte [= Monte Coglians] (SCHÖNLAUB & FLAJS, 1975; KREUTZER, 1990: p. 296), N 46°36'29" / E 12°53'17"; Seewarte (N 46°36'35" / E 12°52'15"), southern continuation of Seekopf, Biegengebirge (BANDEL, 1969; SCHÖNLAUB et al., 2004).

**Derivation of name:** After Mount Hohe Warte (KREUTZER, 1992a: p. 270).

**Synonyms:** Riffkalk-Facies der Stockwerke H-G-H [partim] (STACHE, 1884, p. 339); Korallenriffkalk am Wolayer- u. Seekopf-Thörl [partim] (FRECH, 1887: p. 700); unterdevonischer Riffkalk [partim] (FRECH, 1894b: p. 229); Riffkalk mit *Karpinskya conjugula* (GAERTNER, 1931); Schichten mit *K. conjugula* (PÖLSLER, 1967); Helle Crinoiden-Kalke (BANDEL, 1969); bioclastic Ist. (SCHÖNLAUB, 1980b: Fig. 3); Heller Crinoidenschuttkalk mit *Karpinskya conjugula* (SCHÖNLAUB, 1985a); Riffkalke des Prag (SCHÖNLAUB, 1985a); Heller Crinoidenschuttkalk (KREUTZER, 1990: Fig. 19); Riffkalk (KREUTZER, 1990: Fig. 19); Hohe Warte Formation (SUTTNER, 2007b; not formalized).

**Lithology:** Massive, light grey limestone.

**Fossils:** Calcareous algae brachiopods, conodonts, corals, crinoids, cyanobacteria, gastropods, stromatoporoids, trilobites.

**Origin, facies:** Marine limestone, neritic unit with patch reefs; Southern Shallow-water Facies (KREUTZER, 1992a).

**Chronostratigraphic age:** Pragian.

**Biostratigraphy:** ?*serratus-celtibericus* conodont zones (SUTTNER, 2007b).

**Thickness:** 350 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** According to its microfacies a reefal and a crinoidal limestone unit are described (VAI, 1967; BANDEL, 1969); within the paper of BANDEL (1969) this unit was divided into "Schicht 1-20".

**Underlying unit(s):** Rauchkofel Limestone (conformable contact).

**Overlying unit(s):** Seewarte Limestone (conformable contact).

**Lateral unit(s):** Gamskofel Limestone, Kellerwand Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** GORTANI (1912), PICHL (1929), VAI (1968, 1998), KODSI (1971), SCHÖNLAUB (1971–1973, 1984b, 1991), ELLERMANN (1992), LATZ (1992), KREUTZER et al. (1997, 2000), SCHÖNLAUB & KREUTZER (1997), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), MAY et al. (2004), SUTTNER (2005), CARULLI (2006), VENTURINI (2006), HUBMANN & SUTTNER (2007).

### Kellerwand-Kalk / Kellerwand Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; description is given by SCHÖNLAUB (1985a: p. 43); facies of this limestone at Mount Cellon is observed by KREUTZER (1990: p. 280) and SCHÖNLAUB et al. (2004: p. 22); summary of unit is given by KREUTZER (1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Lower part of the Kellerwand – located between Obere Valentinalm and Eiskarkopf (N 46°36'54" / E 12°54'39"), Cellon avalanche gully, Kleiner Pal (KREUTZER, 1990: p. 282, 1992b).

**Derivation of name:** After the lower Kellerwand below the Eiskar glacier (KREUTZER, 1989).

**Synonyms:** Calcari stratificati giallastrati [partim] (SPALLETTA et al., 1982); yellow bedded limestone [partim] (SPALLETTA & VENTURINI, 1989); Gelbe Plattenkalke der Kellerwand (KREUTZER, 1990).

**Lithology:** Yellow tentaculite limestone with bioclastic layers.

**Fossils:** Bivalves, brachiopods, conodonts, corals, echinoderms, ostracods, nautiloids, tentaculites (dacryoconarids; KREUTZER, 1992b: p. 28), trilobites.

**Origin, facies:** Marine limestone; following KREUTZER (1992a) the depositional environment corresponds with the Transitional Facies.

**Chronostratigraphic age:** Pragian–lower Emsian.

**Biostratigraphy:** *serotinus* and *patulus* conodont zones (KREUTZER, 1990).

**Thickness:** 145 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Rauchkofel Limestone (conformable contact).

**Overlying unit(s):** Vinz Limestone (conformable contact).



**Lateral unit(s):** Hohe Warte Limestone, Seewarte Limestone, Findenig Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003).

### Findenig-Kalk / Findenig Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; limestone deposits of Mount Findenig are well studied by PÖLSLER (1969a); facies analysis of Findenig Limestone is provided from Oberbuchach and Findenigkofel by SCHÖNLAUB (1985b: p. 357) and SCHÖNLAUB et al. (2004: p. 24); a summary of the unit is given by KREUTZER (1992b: p. 28).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Herma-gor).

**Type section:** -

**Reference section(s):** Mount Findenig (N 46°35'42" / E 13°06'14"), Rauchkofel Boden section, Valentintörl section, Oberbuchach II, Hoher Trieb, Seekopf, Monte Zermula (see VAI, 1980: p. 80; SCHÖNLAUB, 1985b: p. 357; SCHÖNLAUB et al., 2004: p. 24, 28).

**Derivation of name:** After Mount Findenig.

**Synonyms:** Grauer und rother Kramenzelkalk (FRECH, 1894b: p. 227); fleischrote oder lichtgraue, plattige Netzkalke (GEYER, 1903); graue und rote Netzkalke (SPITZ, 1909); Devonischer Netzkalk mit Goniatiten (GAERTNER, 1931); Netzkalke mit Goniatiten (HABERFELNER & HERITSCH, 1932b); 'Roter Flaser- und Knollenkalk' (BANDEL, 1974: p. 96); reddish nodular limestone (SCHÖNLAUB, 1980b).

**Lithology:** Red flaser and nodular limestone (HUBMANN et al., 2003: p. 34).

**Fossils:** Cephalopods, conodonts, foraminifers, ostracods, tentaculites (dacryoconarids; SCHÖNLAUB et al., 2004: p. 53).

**Origin, facies:** Marine limestone, pelagic unit (Pelagic Carbonate Facies).

**Chronostratigraphic age:** Pragian–Emsian.

**Biostratigraphy:** *serratus* and *kitabicus* conodont zones (PÖLSLER, 1969b).

**Thickness:** 40–60 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Boden Limestone (conformable contact), Nöbling Formation (conformable contact), Middle and Upper Bischofalm Shale (conformable contact).

**Overlying unit(s):** Hohe Trieb Formation (conformable contact), Valentin Limestone (conformable contact).

**Lateral unit(s):** Kellerwand Limestone, Vinz Limestone, Zollner Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** PÖLSLER (1969b), BANDEL & BECKER (1975), RANTITSCH (1992a), FERRETTI et al. (1999), HISTON et al. (1999), SCHÖNLAUB & HISTON (2000).

### Zollner-Formation / Zollner Formation

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Valid (SCHÖNLAUB, 1985a: p. 44); detailed facies description by SCHÖNLAUB & HISTON (2000) and SCHÖNLAUB et al. (2004).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Herma-gor).

**Type section:** Section near Lake Zollner (N 46°36'18" / E 13°04'11").

**Reference section(s):** Gundesheim Alm road (Oberbuchach section), Findenig, Hoher Trieb, southern side of Hohe Warte, Dellach Alm, Kronhof- and Nöblinggraben (SCHÖNLAUB, 1969a).

**Derivation of name:** After Lake Zollner (SCHÖNLAUB, 1985a: p. 78).

**Synonyms:** -

**Lithology:** Greyish green lydites and siliceous shales.

**Fossils:** Conodonts, radiolarians (SCHÖNLAUB, 1985a: p. 44).

**Origin, facies:** Marine, pelagic unit (Distal Siliciclastic Facies).

**Chronostratigraphic age:** Lochkovian–Tournaisian (regarding to the age constraint, the reader is referred to SCHÖNLAUB & HISTON, 2000: p. 23 and SCHÖNLAUB et al., 2004).

**Biostratigraphy:** -

**Thickness:** > 100 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Middle and Upper Bischofalm Shale (conformable contact).

**Overlying unit(s):** Hochwipfel Formation (unconformable contact).

**Lateral unit(s):** Findenig Limestone, Valentin Limestone, Pal Limestone, Kronhof Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1969a, 1991), HERZOG (1988), VAI (1998), SCHÖNLAUB & HISTON (1999), MADER & NEUBAUER (2004), VENTURINI (2006).

### Seewarte-Kalk / Seewarte Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; first mentioned by STACHE (1884); the diverse gastropod fauna of this unit was first observed in the rubble of the Seewarte by SPITZ (1907); detailed description is given by KREUTZER (1990: p. 295); later included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b: p. 28).

**Type area:** ÖK50-UTM, map sheets 3108 Sillian, 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach).

**Type section:** -

**Reference section(s):** Section near Rifugio Lambertenghi e Romanin at the base of Seewarte – Cima Lastrons del Lago (KREUTZER, 1992a: p. 270), N 46°36'30" / E 12°52'14".

**Derivation of name:** After Mount Seewarte.

**Synonyms:** Riffkalk-Facies der Stockwerke H-G-H [partim] (STACHE, 1884: p. 339); schwarzer Gastropodenkalk (GAERTNER, 1931: p. 144); schwarze Kalke mit ihrem reichlichen Vorkommen von Hercynellen (GAERTNER, 1931: p. 144); Hercynellenkalk-Niveau (KREUTZER, 1990).

**Lithology:** Black bituminous limestone.

**Fossils:** Calcareous algae, bivalves, corals, crinoids, gastropods, ostracods (JHAVERI, 1969; KREUTZER, 1992b: p. 28).

**Origin, facies:** Marine limestone, neritic unit within the Southern Shallow-water Facies (SCHÖNLAUB et al., 2004: p. 19).

**Chronostratigraphic age:** Lower Emsian (ERBEN et al., 1962; KREUTZER, 1990: p. 295; SCHÖNLAUB et al., 2004: p. 12).

**Biostratigraphy:** -

**Thickness:** 40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Hohe Warte Limestone (conformable contact).

**Overlying unit(s):** Lambertenghi Limestone (conformable contact), Eiskar Limestone (conformable contact).

**Lateral unit(s):** Gamskofel Limestone, Kellerwand Limestone, Vinz Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** PÖLSLER (1967), SCHÖNLAUB (1971–1973, 1984b, 1985a, 1991), KREUTZER et al. (1997, 2000), SCHÖNLAUB & KREUTZER (1997), VAI (1998), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), CARULLI (2006).

### Vinz-Kalk / Vinz Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; documented by SCHÖNLAUB (1969a); mapped by KREUTZER & SCHÖNLAUB (1984); name of the unit was first used by KREUTZER (1992a: p. 271).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Eiskar cavern (N 46°36'53" / E 12°54'36") southwest of Eiskar Hut and northwest of Eiskar glacier, upper part of Cellon avalanche gully (KREUTZER, 1992a; SCHÖNLAUB et al., 2004).

**Derivation of name:** After the Vinz peak at the lower Kellerwand (KREUTZER, 1992a: p. 271).

**Synonyms:** Dunkler Plattenkalk (SCHÖNLAUB, 1969a: p. 288); Dunkelgrauer, geflaserter Plattenkalk im Wechsel

mit Schuttbrekzien (KREUTZER & SCHÖNLAUB, 1984); Plattenkalke der Unteren Kellerwand [partim] (KREUTZER, 1990: p. 286); calcari stratificati giallastrì [partim] (SPALLETTA et al., 1982); yellow bedded limestone [partim] (SPALLETTA & VENTURINI, 1989).

**Lithology:** Dark grey platy limestone with debris layers (KREUTZER, 1992b: p. 29).

**Fossils:** Bivalves, cephalopods, corals, conodonts, ecinoderms, foraminifers, ostracods, tentaculites.

**Origin, facies:** Marine limestone, following KREUTZER (1992a) the depositional environment corresponds with the Transitional Facies.

**Chronostratigraphic age:** Emsian (KREUTZER, 1990).

**Biostratigraphy:** -

**Thickness:** 120 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kellerwand Limestone (conformable contact).

**Overlying unit(s):** Cellon Limestone (conformable contact), Freikofel Limestone (conformable contact).

**Lateral unit(s):** Seewarte Limestone, Eiskar Limestone, Findenig Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** KREUTZER (1990), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003).

### Lambertenghi-Kalk / Lambertenghi Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; known since STACHE (1884); facies described by POHLER (1982), KREUTZER (1990, 1992a) and SCHÖNLAUB et al. (2004); the name of this unit was first used by KREUTZER (1992a: p. 270, 1992b: p. 29) and SCHÖNLAUB (1992), as Lambertenghi-Kalk and Lambertenghi Limestone, respectively.

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Area of Rifugio Lambertenghi e Romanin, South of Lake Wolayer (western walls of Mount Seewarte and opposite side, N 46°36'22" / E 12°52'15"), section along Seekopf (SCHÖNLAUB, 1971–1973; KREUTZER, 1992a: p. 270).

**Derivation of name:** After Rifugio Lambertenghi e Romanin.

**Synonyms:** Riffkalk-Facies der Stockwerke H-G-H [partim] (STACHE, 1884: p. 339); Riffkalk mit *Karpinskya consuelo* (GAERTNER, 1931); Schichten mit *K. consuelo* (PÖLSLER, 1967); Gebankter Laminitkalk mit *Karpinskya consuelo* (SCHÖNLAUB, 1971–1973); Consuelo Lst. (SCHÖNLAUB, 1980: Fig. 3); Consuelo-Laminit-Kalk (SCHÖNLAUB, 1985a: Fig. 10); Gebankter Laminitkalk (SCHÖNLAUB, 1985a: p. 42); gebankte Laminitkalke (KREUTZER, 1990); Laminit-Kalk (SCHÖNLAUB, 1991: p. 105); Laminierte geschichtete Kalke und Dolomite (SCHÖNLAUB, 1991: p. 105); Laminierte Kalke

(SCHÖNLAUB, 1991: p. 119); Consuelo-Laminite (KREUTZER, 1992a: p. 270).

**Lithology:** Well bedded laminated limestone, birdseye limestone, crinoidal debris limestone.

**Fossils:** Calcareous algae, bivalves, brachiopods (e.g., *Karpinskia consuelo*), corals, echinoderms, foraminifers, gastropods, ostracods, stromatoporoids (KREUTZER, 1992b: p. 29).

**Origin, facies:** Marine limestone, neritic unit belonging to the Southern Shallow-water Facies (KREUTZER, 1990).

**Chronostratigraphic age:** Emsian (KREUTZER, 1992a: p. 270; SCHÖNLAUB et al., 2004: p. 19).

**Biostratigraphy:** -

**Thickness:** 130 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Seewarte Limestone (conformable contact).

**Overlying unit(s):** Spinotti Limestone (conformable contact).

**Lateral unit(s):** Gamskofel Limestone, Eiskar Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** BANDEL (1972), SCHÖNLAUB (1984b), VAI (1998), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004), SUTTNER & KIDO (2011).

### Spinotti-Kalk / Spinotti Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; first observed by STACHE (1884) and later by GAERTNER (1931); facies described by POHLER (1982) and KREUTZER (1990, 1992a); name of this unit first mentioned by KREUTZER (1992b: p. 30).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach (Italian side)).

**Type section:** -

**Reference section(s):** Trail along Sentiero Spinotti between Rifugio Lambertenghi e Romanin and Rifugio Giovanni e Olinto Marinelle (N 46°36'06" / E 12°52'26"), Hohe Warte (KREUTZER, 1992a).

**Derivation of name:** After Sentiero Spinotti.

**Synonyms:** Riffkalk-Facies der Stockwerke H-G-H [partim] (STACHE, 1884: p. 339); Pentamerenkalk (GAERTNER, 1931: p. 148); Riffkalk mit *Pentamerus* aff. *pseudobaschkiricus* (GAERTNER, 1931: p. 147); La serie calcarea di M. Zermula [partim] (FERRARI & VAI, 1966); Stromatoporen-Korallen-Crinoidenkalk (SCHÖNLAUB, 1971–1973); Gebankter Birdseye-Amphiporen-Brachiopodenkalk (SCHÖNLAUB, 1971–1973); Pentamerus Lst. (SCHÖNLAUB, 1980: Fig. 3); Amphipora Lst. (SCHÖNLAUB, 1980b: Fig. 3); Korallen/Crinoiden-K. (SCHÖNLAUB, 1985a: Fig. 10); Amphipora-Kalk (SCHÖNLAUB, 1985a: Fig. 10); Stromatoporen-Korallen-Crinoidenschutt-kalk (SCHÖNLAUB, 1985a: p. 42); Gebankter Birdseye-Amphiporen-Brachiopoden-Kalk (SCHÖNLAUB, 1985a: p. 42); Crinoiden-Kalk and Birdseye-Kalk (KREUTZER, 1990); Korallen-Crinoidenkalk (SCHÖNLAUB, 1991: p. 105); Amphiporenkalk (SCHÖNLAUB, 1991: p. 105); Fossilschutt-kalke (SCHÖNLAUB, 1991: p. 119); "Birdseye"-Kalke (SCHÖNLAUB, 1991: p. 119); Geschichtete "Birdseye"-kalke (SCHÖNLAUB, 1991: p. 119).

**Lithology:** Massive limestone, layers of crinoidal debris and *Amphipora* limestone, birdseye limestone.

**Fossils:** Calcareous algae, bivalves, brachiopods, corals (rugose and tabulate), echinoderms, gastropods, stromatoporoids.

**Origin, facies:** Marine limestone, neritic unit (Southern Shallow-water Facies).

**Chronostratigraphic age:** Eifelian–lower Givetian (VAI, 1963; BANDEL, 1972; SCHÖNLAUB et al., 2004: p. 15–16).

**Biostratigraphy:** -

**Thickness:** 220 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** Spinotti A–D and Amphipora Limestone; see remarks.

**Underlying unit(s):** Lambertenghi Limestone (conformable contact).

**Overlying unit(s):** Kellergrat Reef Limestone (conformable contact); Kronhof Limestone (unconformable contact; SCHÖNLAUB & KREUTZER, 1993: Fig. 5).

**Lateral unit(s):** Gamskofel Limestone, Eiskar Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** According to the lithostratigraphic subdivision, the Spinotti Limestone is composed of crinoidal and bioclastic limestones (subdivided into four units based on its facies characters: Spinotti A–D) and "birdseye limestone" with *Amphipora* (SCHÖNLAUB et al., 2004: p. 13–16).

**Complementary references:** VAI (1967, 1998), SCHÖNLAUB (1984b), HUBMANN & FENNINGER (1993), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), VENTURINI (2006).

### Eiskar-Kalk / Eiskar Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; the name of this limestone was first used on the map of KREUTZER & SCHÖNLAUB (1984); well described by SCHÖNLAUB (1985a: Fig. 10, p. 43) and revised by KREUTZER (1990: p. 306, 1992a); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Between Kellerwarte and Plöckenpass (KREUTZER & SCHÖNLAUB, 1984).

**Derivation of name:** After the Eiskar at the Kellerspitzen in the area of the upper Kellerwand cliff (SCHÖNLAUB, 1991: p. 118).

**Synonyms:** Emsium-Kalk; Eifelium-Kalk; Givetium-Kalk der Kellerspitzen (cf. KREUTZER 1990: p. 306).

**Lithology:** Bioclastic limestone, birdseye limestone.

**Fossils:** Calcareous algae, bivalves, corals, echinoderms, gastropods (KREUTZER, 1992b: p. 29).

**Origin, facies:** Marine limestone, neritic unit of the Southern Shallow-water Facies (KREUTZER, 1990).

**Chronostratigraphic age:** Emsian–lower Givetian (SCHÖNLAUB et al., 2004: p. 16).

**Biostratigraphy:** -

**Thickness:** 330 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Seewarte Limestone (conformable contact).

**Overlying unit(s):** Kellergrat Reef Limestone (conformable contact).

**Lateral unit(s):** Lambertenghi Limestone, Spinotti Limestone, Vinz Limestone, Cellon Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1985c), SCHÖNLAUB & HISTON (2000).

### Freikofel-Kalk / Freikofel Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; mentioned by BANDEL (1972) and SCHÖNLAUB (1985a: p. 43); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b: p. 30); lithology and facies described by SCHÖNLAUB et al. (2004).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Mount Freikofel [= Cuelat] (SCHÖNLAUB et al., 2004), N 46°36'03" / E 12°58'39"; Pal Grande, Pal Piccolo, Creta di Timau (PERRI & SPALLETTA, 1998a).

**Derivation of name:** After Mount Freikofel (SCHÖNLAUB, 1985a: p. 43).

**Synonyms:** 'Lithoklastkalk' (BANDEL, 1974: p. 101).

**Lithology:** Light red to greyish pelagic limestone (KREUTZER, 1992b).

**Fossils:** Cephalopods, conodonts, corals, crinoids, trilobites.

**Origin, facies:** Marine limestone, gravity flow deposits belonging to the Pelagic Carbonate Facies (KREUTZER, 1992a: p. 272; SCHÖNLAUB et al., 2004: p. 45).

**Chronostratigraphic age:** Eifelian–Givetian.

**Biostratigraphy:** *costatus* conodont zone (PERRI & SPALLETTA, 1998a).

**Thickness:** > 100 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Vinz Limestone (conformable contact).

**Overlying unit(s):** Pal Limestone (conformable contact).

**Lateral unit(s):** Cellon Limestone, Findenig Limestone, Hohe Trieb Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HISTON (2000), BRIME et al. (2008).

### Cellon-Kalk / Cellon Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; first detailed profiles by BANDEL (1972, 1974); mapped by KREUTZER & SCHÖNLAUB (1984); lithology and facies described by SCHÖNLAUB (1985a) and KREUTZER (1992a); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b: p. 30).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3112 Villach, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal, 3118 Arnoldstein (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor, 200 Arnoldstein).

**Type section:** Upper part of Cellon avalanche gully (KREUTZER, 1992a), N 46°36'31" / E 12°56'08".

**Reference section(s):** Lower Kellerwand cliff (Obere Valentinalm to Eiskarkopf), Kleiner Pal (KREUTZER & SCHÖNLAUB, 1984; KREUTZER, 1990).

**Derivation of name:** After Mount Cellon.

**Synonyms:** 'Lithoklastkalk' (BANDEL, 1974: p. 101); Kunzkopf-Kalk (KREUTZER, 1990).

**Lithology:** Massive grey limestone with pelagic biogenes with debris layers (KREUTZER, 1992b).

**Fossils:** Bivalves, cephalopods, corals, conodonts, echinoderms, foraminifers, gastropods, stromatoporoids, trilobites.

**Origin, facies:** Marine limestone, pelagic unit (Transitional Facies).

**Chronostratigraphic age:** Eifelian–Givetian.

**Biostratigraphy:** *partitus*, *costatus* and *varcus* conodont zones (KREUTZER, 1990).

**Thickness:** 210 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Vinz Limestone (conformable contact).

**Overlying unit(s):** Pal Limestone (conformable contact).

**Lateral unit(s):** Eiskar Limestone, Kellergrat Reef Limestone, Freikofel Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** KREUTZER et al. (1997, 2000), VAI (1998), SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004).

### Hohe Trieb-Formation / Hohe Trieb Formation

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Valid; well described by PÖLSLER (1969a) and SCHÖNLAUB (1969a); mapped by SCHÖNLAUB (1981); named by SCHÖNLAUB (1985a: p. 43); unit formalized by KREUTZER (1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** Hoher Trieb (SCHÖNLAUB, 1969a), N 46°35'46" / E 13°03'31".

**Reference section(s):** Bischofalm, Tristanköpf (SCHÖNLAUB, 1969a); Mount Findenig (PÖLSLER, 1969a).

**Derivation of name:** After Mount Hoher Trieb (SCHÖNLAUB, 1969a).

**Synonyms:** Formazione di Monte Lodin (SELLI, 1963); “20m-Bank” (PÖLSLER, 1969a: Tab. 1, 4, p. 366); gebankte Kalke mit Lydit (PÖLSLER, 1969a: Tab. 1, 4, p. 366); Blockhorizont (PÖLSLER, 1969a: Tab. 4, p. 369); massiger Kalk mit verkieselten Korallen (PÖLSLER, 1969a: Tab. 1); Hoher Trieb-Kalk (SCHÖNLAUB, 1981); tentaculite pelagic limestone [partim] (SPALLETTA & VENTURINI, 1989); Hoher Trieb Formation (HÜNEKE, 2006: p. 154).

**Lithology:** Flaser and platy limestone with clay and chert layers (KREUTZER, 1992b).

**Fossils:** Cephalopods, conodonts, corals, crinoids, trilobites, stromatoporoids; silicified corals and stromatoporoids of Mount Findenig are known since FRECH (1894).

**Origin, facies:** Marine limestone, pelagic unit (Pelagic Carbonate Facies).

**Chronostratigraphic age:** Eifelian–Givetian (age constraint follows the conodont analysis and zonation from equivalent strata of Mount Findenig by PÖLSLER, 1969a: Tab. 1).

**Biostratigraphy:** -

**Thickness:** 30–40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Findenig Limestone (conformable contact).

**Overlying unit(s):** Pal Limestone (unconformable contact).

**Lateral unit(s):** Freikofel Limestone, Pal Limestone, Valentin Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1991), VAI (1998), SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004).

### Valentin-Kalk / Valentin Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; the name of this unit was introduced on the map of SCHÖNLAUB (1971–1973); conodont stratigraphy by SCHÖNLAUB (1980b) and GÖDDERTZ (1982); lithological description by SCHÖNLAUB (1985a); mentioned by KREUTZER (1990, 1992a); summary of unit is provided by KREUTZER (1992b: p. 30–31); facies analysis (HÜNEKE, 2001, 2006; SCHÖNLAUB et al., 2004: p. 59).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Obere Valentinalm, Wolayer “Glacier” section (SCHÖNLAUB et al., 2004: p. 59); sections 13 km NE of Paluzza (Malpasso, Poccis, Pramasio, Rio Boreado) (PERRI & SPALLETTA, 1998a: p. 116, 118, 119).

**Derivation of name:** After the Valentin Törl between Lake Wolayer the Valentin Valley (SCHÖNLAUB, 1980b: p. 45).

**Synonyms:** “Grauer Styliolinen-Flaserkalk” (BANDEL, 1974: p. 96); Pramasio calcirudite (SPALLETTA & PERRI, 1998a).

**Lithology:** Well bedded limestones (wackestone), nodular phosphorite horizon (at Givetian/Frasnian boundary).

**Fossils:** Brachiopods, conodonts, echinoderms, gastropods, ostracods, styliolinids, trilobites (SCHÖNLAUB et al., 2004: p. 59).

**Origin, facies:** Marine limestone, Pelagic Carbonate Facies (POHLER & SCHÖNLAUB, 2001).

**Chronostratigraphic age:** Eifelian–Givetian.

**Biostratigraphy:** *costatus* to lower *hassi* conodont zones (GÖDDERTZ, 1982; SCHÖNLAUB et al., 2004: p. 60–61).

**Thickness:** 15 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Findenig Limestone (conformable contact).

**Overlying unit(s):** Pal Limestone (unconformable contact).

**Lateral unit(s):** Hohe Trieb Formation, Zollner Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** PÖLSLER (1969a, b), BANDEL & BECKER (1975), SCHÖNLAUB (1985b, 1999), JOACHIMSKI et al. (1994), SCHÖNLAUB & KREUTZER (1994b), PERRI & SPALLETTA (1998a), SPALLETTA & PERRI (1998b), SCHÖNLAUB & HISTON (2000), VENTURINI (2006), HÜNEKE (2007), BRIME et al. (2008).

### Feldkogel-Kalk / Feldkogel Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; known since FRECH (1887); observed by BANDEL (1972); facies analysis by KREUTZER (1992a); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Feldkogel south of the village of Gundersheim (KREUTZER, 1992a: p. 272), N 46°37'16" / E 13°07'23".

**Derivation of name:** After Mount Feldkogel (KREUTZER, 1992a).

**Synonyms:** Dolomitische Schichten des Pollinigg (FRECH, 1887: p. 690).

**Lithology:** Algal laminite with dolomite layers (KREUTZER, 1992b).

**Fossils:** Conodonts, foraminifers, ostracods, stromatolites.

**Origin, facies:** Marine limestone, intertidal, neritic unit (Northern Shallow-water Facies).

**Chronostratigraphic age:** Eifelian–Upper Devonian.

**Biostratigraphy:** Upper Devonian is based on the occurrence of *Palmatolepis* sp. from sediments of the Mooskofel (KREUTZER, 1990).

**Thickness:** > 330 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Gamskofel Limestone (conformable contact).

**Overlying unit(s):** Plotta Lydite (unconformable contact).

**Lateral unit(s):** Gamskofel Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1985a), RAN-TITSCH (1992a), SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004).

### Kellergrat-Riffkalk / Kellergrat Reef Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; facies described by KREUTZER (1990, 1992a); summary of unit is provided by KREUTZER (1992b: p. 31); the formation name Kellergrat-Riffkalk was first mentioned by KREUTZER (1992a: p. 271); later it has been continuously used, e.g., by FLÜGEL & HUBMANN (1994), KREUTZER et al. (1997) and SCHÖNLAUB (1992).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** Kellergrat (located between the Kellerspitzen to the West and the Kollinkofel to the East, N 46°36'39" / E 12°54'04") and Hohe Warte (KREUTZER, 1990); abandoned trail #149 to Rifugio Marinelli (SCHÖNLAUB et al., 2004: p. 46); Monte Zermula and Monte Zuc della Guardia (Canson di Lanza pass) (FERRARI & VAI, 1966).

**Derivation of name:** After the Kellergrat which is located between the Kellerspitzen and Kollinkofel (KREUTZER, 1990: p. 295).

**Synonyms:** La serie calcarea di M. Zermula [partim] (FERRARI & VAI, 1966); Stromatoporen-Korallen-Riffkalk im Gipfelbereich der Hohen Warte (SCHÖNLAUB, 1971–1973); Phillipsastrea Lst. (SCHÖNLAUB, 1980b: Fig. 3); Phillipsastrea-Kalk (KREUTZER & SCHÖNLAUB, 1984); Stromatoporen/Korallenschutt-K. (SCHÖNLAUB, 1985a: Fig. 10); Phillipsastrea/Brachiop.-K. (SCHÖNLAUB, 1985a: Fig. 10); Riff-Kalk (KREUTZER, 1990); Korallenkalk (SCHÖNLAUB, 1991: p. 119); Korallen-Stromatoporen-Kalk und Phillipsastrea-Kalk (KREUTZER, 1992a: p. 271); Riffkalke im Gipfelbereich der Hohen Warte und der Kellerwände (OEKENTORP-KÜSTER & OEKENTORP, 1992: p. 237); Givetische Rindenkoralkalke der Hohen Warte und des Kollinkofels (OEKENTORP-KÜSTER & OEKENTORP, 1992: p. 238); Rindenkoralkalke im Bereich der Hohen Warte, der Kellerspitzen und des Kollinkofel (OEKENTORP-KÜSTER & OEKENTORP, 1992: p. 238); Rindenkoralkalke des Kollinkofels (OEKENTORP-KÜSTER & OEKENTORP, 1992: p. 239, 240); Rindenkoralkalke des Ober-Givetiums der Kellerwände und des Kollinkofels (OEKENTORP-KÜSTER & OEKENTORP, 1992: p. 240).

**Lithology:** Massive reef limestone (KREUTZER, 1992b: p. 31).

**Fossils:** Brachiopods, calcareous algae, calcispheres, conodonts, corals, ecinoderms, gastropods, stromatopoids (KREUTZER, 1992b: p. 31; OEKENTORP-KÜSTER & OEKENTORP, 1992).

**Origin, facies:** Marine limestone, neritic unit belonging to the Southern Shallow-water Facies (SCHÖNLAUB, 1985a: p. 42).

**Chronostratigraphic age:** Lower Givetian–Frasnian (SCHÖNLAUB, 1985a: p. 43; SCHÖNLAUB et al., 2004: p. 16).

**Biostratigraphy:** *gigas* conodont zone (KREUTZER, 1990).

**Thickness:** > 180 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Spinotti Limestone (conformable contact), Eiskar Limestone (conformable contact).

**Overlying unit(s):** Marinelli Limestone (conformable contact), Kollinkofel Limestone (conformable contact).

**Lateral unit(s):** Gamskofel Limestone, Cellon Limestone, Pal Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** FLÜGEL (1956, 1958), VAI (1963, 1967, 1971, 1998), PÖLSLER (1967), FERRARI (1968), BANDEL (1972), GALLI (1985), SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), VENTURINI (2006).

### Pal-Kalk / Pal Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; known since FRECH (1887); described by GAERTNER (1931); facies analysis by KREUTZER (1992a); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b); well studied for conodonts by PERRI & SPALLETTA (1998a, b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3111 Spittal an der Drau, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Herma-gor).

**Type section:** -

**Reference section(s):** Grosser Pal (Pal Grande), 3.6 km east of the Plöckenpass (N 46°35'56" / E 12°59'26"), Kleiner Pal, Cellon, section west of the Valentintörl near southern slope of Mount Rauchkofel, Grüne Schneid (Cresta Verde), Kronhofgraben, Casera Pramosio Alta, Malga Poccis, Cava Canteoniera, Casera Malpasso, Collinetta di sotto section near Plöckenpass (all localities summarized by PERRI & SPALLETTA, 1998a, b).

**Derivation of name:** After Mount Pal (FRECH, 1887).

**Synonyms:** Clymenienkalk am Gross-Pal (FRECH, 1887: p. 700); Clymenienkalk (PÖLSLER, 1967); 'Kalk mit phosphatischen Knollen' (BANDEL, 1974: p. 97); 'Goniatiten-Flaserkalk' (BANDEL, 1974: p. 97); Goniatite Flaser-Ist. (SCHÖNLAUB, 1980b: Fig. 3); Pramosio calcirudite and clymenid- and goniatid-bearing pelagic limestone (SPALLETTA & PERRI, 1998c); Pal Limestone Formation (HÜNEKE, 2006).

**Lithology:** Limestone beds (mudstone and wackestone), thin biosparitic and quartz-rich layers, black shale.

**Fossils:** Bivalves, clymeniids, conodonts, corals (rare), echinoderms, goniatites, ostracods, styliolinids, trilobites.

**Origin, facies:** Open marine limestone, pelagic unit (Transitional Facies and Pelagic Carbonate Facies).

**Chronostratigraphic age:** Frasnian–Famennian.

**Biostratigraphy:** Ammonoid zones (*acuticostata* and *piriformis Clymenia* zones; upper *paradoxa* and *prorsum Woeklumeria* zones); upper *hassi* to *praesulcata* conodont zones.

**Thickness:** > 100 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Cellon Limestone (conformable contact), Freikofel Limestone (conformable contact), Hohe Trieb Formation (unconformable contact), Valentin Limestone (unconformable contact).

**Overlying unit(s):** Kronhof Limestone (conformable contact).

**Lateral unit(s):** Kellergrat Reef Limestone, Kollinkofel Limestone, Hohe Trieb Formation, Valentin Limestone, Zollner Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** FRECH (1894b, 1902), GAERTNER (1927, 1931), PÖLSLER (1967, 1969a, b), LANGER (1969), SCHÖNLAUB (1969b, 1985a, b, 1999), VAI (1971, 1998), BANDEL & BECKER (1975), PERRI & SPALLETTA (1981, 1991, 1998c, d, e, f), KREUTZER (1990), DREESEN (1992), FEIST (1992), KORN (1992, 1999), RANTITSCH (1992a), SCHÖNLAUB et al. (1992, 2004), JOACHIMSKI et al. (1994), PERRI et al. (1998), SPALLETTA & PERRI (1998b, 1998d), SPALLETTA et al. (1998a, b), SCHÖNLAUB & HISTON (1999, 2000), SCHÖNLAUB & KORN (1999), KAISER et al. (2006), VENTURINI (2006), BRIME et al. (2008).

#### Marinelli-Kalk / Marinelli Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; name was introduced by KREUTZER (1992a: p. 271); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach (Italian side)).

**Type section:** -

**Reference section(s):** Southern slope of Kellerspitzen east of Rifugio Giovanni e Olinto Marinelli (KREUTZER, 1992b).

**Derivation of name:** After Rifugio Giovanni e Olinto Marinelli (KREUTZER, 1992a: p. 271).

**Synonyms:** -

**Lithology:** Indistinctly bedded loferites and crinoidal debris limestone (KREUTZER, 1992b).

**Fossils:** Calcareous algae, conodonts, echinoderms, gastropods.

**Origin, facies:** Marine limestone, neritic unit (Southern Shallow-water Facies).

**Chronostratigraphic age:** Uppermost Frasnian–Tournaisian.

**Biostratigraphy:** -

**Thickness:** 10–20 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kellergrat Reef Limestone (conformable contact).

**Overlying unit(s):** Plotta Lydite (unconformable contact); Kronhof Limestone (KREUTZER, 1992a: p. 271).

**Lateral unit(s):** Kollinkofel Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & HISTON (2000), HUBMANN et al. (2003), SCHÖNLAUB et al. (2004).

#### Kollinkofel-Kalk / Kollinkofel Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; known since FRECH (1887); facies described by KREUTZER (1990); name was introduced by KREUTZER (1992a: p. 271); included within the summary of the Variscan carbonate sequences in the Carnic Alps (KREUTZER, 1992b).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 197 Kötschach).

**Type section:** -

**Reference section(s):** North-eastern mountain cliffs and southern wall of the Kollinkofel (KREUTZER, 1992a), N 46°36'26" / E 12°54'19".

**Derivation of name:** After Mount Kollinkofel (KREUTZER, 1992a: p. 271).

**Synonyms:** Unteres Oberdevon am Kollinkofel (FRECH, 1887: p. 700); dunkle Rhynchonellenkalke (KREUTZER, 1992a).

**Lithology:** Dark brachiopod-rich limestone (rhynchonellids) with sparry lithoclastic layers (KREUTZER, 1992b: p. 32).

**Fossils:** Brachiopods, conodonts, echinoderms.

**Origin, facies:** Marine limestone, neritic unit (Southern Shallow-water Facies).

**Chronostratigraphic age:** Uppermost Frasnian–Famennian.

**Biostratigraphy:** *gigas* to *postera* conodont zones (KREUTZER, 1990, 1992a).

**Thickness:** > 40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kellergrat Reef Limestone (conformable contact).

**Overlying unit(s):** -

**Lateral unit(s):** Marinelli Limestone, Pal Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** VAI (1998), SCHÖNLAUB & HISTON (2000), SCHÖNLAUB et al. (2004).

#### Kronhof-Kalk / Kronhof Limestone

THOMAS J. SUTTNER, ERIKA KIDO

**Validity:** Invalid; first described by SCHÖNLAUB (1969b, 1985a); mapped by KREUTZER & SCHÖNLAUB (1984); includ-

ed within the summary of the Variscan carbonate sequences in the Carnic Alps by KREUTZER (1992b); additional biostratigraphic data provided by SCHÖNLAUB & KREUTZER (1993).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach, 199 Hermagor).

**Type section:** -

**Reference section(s):** Kronhofgraben section south-east of the village of Würmlach (KREUTZER, 1992a: p. 270), N 46°39'19" / E 13°00'57"; Grüne Schneid (Cresta Verde), Plan di Zermula, Creta di Rio Secco, Rio Chianaletta (SCHÖNLAUB et al., 1991; PERRI & SPALLETTA, 1998a).

**Derivation of name:** After the Kronhofgraben south of Lower Bischofalm and northwest of Mount Hoher Trieb (SCHÖNLAUB, 1969b).

**Synonyms:** Kronhofkalk (KREUTZER & SCHÖNLAUB, 1984); calcari pelagici (VENTURINI, 2006).

**Lithology:** Grey to reddish flaser limestone, black shale at the base ("Kronhof Shale").

**Fossils:** Cephalopods, conodonts, trilobites.

**Origin, facies:** Marine limestone, pelagic unit (Pelagic Carbonate Facies).

**Chronostratigraphic age:** Tournaisian.

**Biostratigraphy:** *gattendorfia* and *merocanites* ammonoid zones; *sulcata* to *isosticha* conodont zones and *anchoralis* conodont zone (SCHÖNLAUB & KREUTZER, 1993).

**Thickness:** Up to 10 m (+ 0.2 m Kronhof Shale at the base of the unit).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Pal Limestone (conformable contact); Marinelli Limestone (KREUTZER, 1992a: p. 271); in the Cima di Plotta section the Kronhof Limestone disconformably overlies the Spinotti Limestone (SCHÖNLAUB & KREUTZER, 1993: Fig. 5).

**Overlying unit(s):** Hochwipfel Formation (unconformable contact); Dimon Formation (unconformable contact).

**Lateral unit(s):** Plotta Lydite, Zollner Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** GAERTNER (1931), GEDIK (1974), KREUTZER (1990), DREESEN (1992), FEIST (1992), KORN (1992, 1999), KRAINER (1992), SCHÖNLAUB et al. (1992, 2004), SCHÖNLAUB (1997), VAI (1998), VENTURINI & SPALLETTA (1998), SCHÖNLAUB & HISTON (1999, 2000), KAISER et al. (2006), SCHÖNLAUB & FORKE (2007).

### Plotta-Lydite / Plotta Lydite

THOMAS J. SUTTNER

**Validity:** Invalid; name "Plotta Fm." introduced and described by SCHÖNLAUB et al. (1991).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach).

**Type section:** -

**Reference section(s):** North and south-east of Cima di Plotta (SCHÖNLAUB & KREUTZER, 1993), N 46°35'24" / E 12°54'30"; surroundings of Rifugio Marinelli and Casera Promosio, Grüne Schneid, quarry "Cava Val di Collina" (N 46°35'34" / E 12°56'27"), abandoned quarry at Casa Cantoniera, quarries "Cava di Marmo", abandoned quarry Malpasso (SCHÖNLAUB et al., 1991).

**Derivation of name:** After Cima di Plotta (SCHÖNLAUB et al., 1991).

**Synonyms:** Lydite (SCHÖNLAUB, 1980b); Plotta Fm. (SCHÖNLAUB et al., 1991); radiolarian cherts (VENTURINI & SPALLETTA, 1998).

**Lithology:** Discontinuous silcrete layers consisting of weakly bedded breccias or massive and laminated cherts (SCHÖNLAUB et al., 1991).

**Fossils:** Radiolarians?

**Origin, facies:** Silcrete regolith, fossil soil facies (SCHÖNLAUB et al., 1991).

**Chronostratigraphic age:** Tournaisian.

**Biostratigraphy:** The above mentioned age was concluded by SCHÖNLAUB et al. (1991: p. 97) based on a mixed conodont fauna (*anchoralis-latus* Zone) from the uppermost limestone bed disconformably overlain by the Plotta Lydite.

**Thickness:** Approx. 3 m

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Feldkogel Limestone (unconformable contact); Gamskofel Limestone (unconformable contact); Marinelli Limestone (unconformable contact); Kronhof Limestone (unconformable contact).

**Overlying unit(s):** Hochwipfel Formation (unconformable contact).

**Lateral unit(s):** Kronhof Limestone.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** KRAINER (1992), SCHÖNLAUB et al. (1992, 2004), SCHÖNLAUB (1997), VAI (1998), SCHÖNLAUB & HISTON (1999, 2000), VENTURINI (2006).

### Hochwipfel-Formation / Hochwipfel Formation

THOMAS J. SUTTNER

**Validity:** Valid; stratigraphic relations discussed by KAHLER & METZ (1955), described in detail by VAN AMEROM et al. (1984), SCHÖNLAUB (1985a), SPALLETTA & VENTURINI (1988), VENTURINI & SPALLETTA (1998), VENTURINI (2006), validated by KREUTZER (1992a).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld, 3117 Nötsch im Gailtal, 3118 Arnoldstein, 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach, 198 Weissbriach, 199 Hermagor, 200 Arnoldstein, 201 Villach, 210 Aßling, 212 Vellach, 213 Bad Eisenkappel).

**Type section:** Mount Hochwipfel of the eastern Carnic Alps (KREUTZER, 1992a: p. 270), N 46°35'40" / E 13°10'35".

**Reference section(s):** Obere Wolayeralm, Kronhoftörl, east of the Obere Bischofalm, Nölblinggraben, Hoher Trieb,



Mount Findenig (N 46°35'42" / E 13°06'14"), Achomitz-Unoka section in the eastern Carnic Alps, Kokragraben near Pöckau, Feistritzgraben and Korpitschgraben, Rio Chianaletta, Casera Collinetta di Sotto, Casera Collinetta di Sopra, Monte Cavallo, Creta di Rio Secco (SCHÖNLAUB, 1985a; KRAINER, 1992); according to MOSHAMMER (1989) sediments of the Hochwipfel Formation can be found in the Karavanke Mountains in the area of the Trögen Klamm at the Smertnik-Bach and section-group E (N 46°28'00" / E 14°30'30").

**Derivation of name:** After the Mountain Hochwipfel (KREUTZER, 1992a: p. 270).

**Synonyms:** Hochwipfelschichten (KAHLER & METZ, 1955); Unter-Karbon-Flysch (TESSENHORN, 1968); Flysch (KUPSCH et al., 1971: Figs. 2, 3, p. 96).

**Lithology:** Turbidite sequence consisting of graded sandstones alternating with siltstone and shale, siliceous shale, lydites (breccias and conglomerates), tuffs.

**Fossils:** Plants, spores.

**Origin, facies:** Marine siliciclastics (flysch), pelagic unit (Distal Siliciclastic Facies).

**Chronostratigraphic age:** Tournaisian–Viséan.

**Biostratigraphy:** *anchoralis* to *texanus* conodont zones.

**Thickness:** > 1,000 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Plotta Lydite, Kronhof Limestone and the Zollner Formation in the Carnic Alps and "Limestones" in the Karavanke Mountains (all units mentioned: unconformable contact which equates with the Variscan Event).

**Overlying unit(s):** Waidegg Formation in the Carnic Alps and Auernig Group in the Karavanke Mountains (all units mentioned: unconformable contact which equates with the Variscan Event).

**Lateral unit(s):** Dimon Formation, Kirchbach Limestone.

**Geographic distribution:** Carnic Alps, Karavanke Mountains.

**Remarks:** -

**Complementary references:** FRECH (1894b), FRANCAVILLA (1966), PÖLSLER (1967, 1969a), TESSENHORN (1971, 1983), GEDIK (1974), SCHÖNLAUB (1979, 1980b, 1982c, 1982d, 1984b, 1991, 1997, 1998), HUNGER (1984), KREUTZER & SCHÖNLAUB (1984), KREUTZER (1990), PERRI & SPALLETTA (1998a, d), VAI (1998), SCHÖNLAUB & HISTON (1999, 2000), MADER & NEUBAUER (2004), SCHÖNLAUB & FORKE (2007), KUTTEROLF et al. (2008).

### Dimon-Formation / Dimon Formation

THOMAS J. SUTTNER

**Validity:** Valid (SPALLETTA et al., 1980).

**Type area:** ÖK50-UTM, map sheet 3109 Oberdrauburg (ÖK50-BMN, map sheets 196 Obertilliach, 197 Kötschach).

**Type section:** Monte Dimon (SPALLETTA et al., 1980), N 46°34'03" / E 13°03'26".

**Reference section(s):** Section along the road from Paularo to Casera Ramaz in the Chiarso valley (PELLIZZER & TOMADIN, 1962; LÄUFER et al., 1993), Plenge (N 46°39'04" /

E 12°54'03"), between Kreuzleitenjoch and Nostra Alm, south of the Stallonkofel (SCHÖNLAUB, 1985a).

**Derivation of name:** After Mount Dimon.

**Synonyms:** Plengeserie (GAERTNER, 1931); Plenge-Dimon Formation (SCHÖNLAUB, 1979); Plenge-Formation (SCHÖNLAUB, 1985a).

**Lithology:** Pillow lavas and breccias, volcanoclastic sediments, green and red argillites (PELLIZZER & TOMADIN, 1962; LÄUFER et al., 1993).

**Fossils:** -

**Origin, facies:** Volcanites and volcanoclastic deposits.

**Chronostratigraphic age:** Viséan; according to VAI (1998) the formation is of Bashkirian age.

**Biostratigraphy:** -

**Thickness:** approx. 300 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Kronhof Limestone (unconformable contact).

**Overlying unit(s):** Waidegg Formation (unconformable contact which equates with the Variscan Event).

**Lateral unit(s):** Hochwipfel Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** FRECH (1894b), PÖLSLER (1967), KRAINER (1992), SCHÖNLAUB et al. (1992, 2004), SCHÖNLAUB (1997, 1998), VENTURINI & SPALLETTA (1998), SCHÖNLAUB & HISTON (1999, 2000), VENTURINI (2006), SCHÖNLAUB & FORKE (2007).

### Kirchbach-Kalk / Kirchbach Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; first described by PÖLSLER (1967); further description and fossil data by SCHÖNLAUB (1985a: p. 44), FLÜGEL & SCHÖNLAUB (1990) and AMLER et al. (1991).

**Type area:** ÖK50-UTM, map sheets 3109 Oberdrauburg, 3110 Kötschach-Mauthen, 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbriach).

**Type section:** -

**Reference section(s):** Plöckentunnel, Hochwipfel (SCHÖNLAUB, 1985a), N 46°35'40" / E 13°10'35".

**Derivation of name:** After the village of Kirchbach.

**Synonyms:** Kalke in den Hochwipfelschichten (PÖLSLER, 1967: p. 40).

**Lithology:** Micritic, light grey nodular limestone; it occurs only in lenticular bodies which laterally grade into silty shale.

**Fossils:** Conodonts, crinoids.

**Origin, facies:** Marine limestone, neritic unit.

**Chronostratigraphic age:** Viséan.

**Biostratigraphy:** According to SCHÖNLAUB (1985a), the conodont assemblage points to Viséan age; no distinct conodont zone is mentioned.

**Thickness:** 8–10 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Hochwipfel Formation (unconformable contact?).

**Overlying unit(s):** Hochwipfel Formation (unconformable contact?).

**Lateral unit(s):** Hochwipfel Formation.

**Geographic distribution:** Carnic Alps.

**Remarks:** -

**Complementary references:** KRÄINER (1992), SCHÖNLAUB et al. (1992, 2004), SCHÖNLAUB (1997), SCHÖNLAUB & HISTON (1999, 2000), SCHÖNLAUB & FORKE (2007).

## Post-Variscan Sequence

### Waidegg-Formation / Waidegg Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; first denomination and formalization by SCHÖNLAUB (1985a: p. 46). Note that SCHÖNLAUB & FORKE (2005: p. 17) renamed the formation in Collendiaul Formation.

**Type area:** ÖK50-UTM, map sheet 3110 Kötschach-Mauthen (ÖK50-BMN, map sheet 197 Kötschach), Carnic Alps, Carinthia.

**Type section:** Outflow of Lake Zollner to the west forming a waterfall and a cliff at approx. 1,760 m (N 46°36'13" / E 13°04'39").

**Reference section(s):** -

**Derivation of name:** After the ridge west of Lake Zollner (Italian: "Collen") in the Gail Valley between Hermagor and Kötschach-Mauthen.

**Synonyms:** Waidegger Gruppe (pars) (FENNINGER et al., 1971) exposed at the northern part of the "Waschbühel" ridge east of Waidegger Alm.

**Remarks:** In Austrian literature, the basal "Auernig beds" (Auernigschichten sensu HERITSCH et al., 1934) have long been described as "Waidegger Group" (FENNINGER et al., 1971). Consequently, SCHÖNLAUB (1985a: p. 46) has defined the Waidegg Formation with the type locality at the outflow of the Lake Zollner. However, the term Waidegger Group has always been intimately connected with the "Waidegger Fauna" (HERITSCH, 1934; HERITSCH et al., 1934; METZ, 1936; GAURI, 1965), which occurs in siltstones of the basal Auernig Formation and is therefore not part of the Waidegg Formation. To avoid further confusion about the lithologic subdivision and the fossil content, the new name "Collendiaul Formation" has been introduced by SCHÖNLAUB & FORKE (2005: p. 17). VENTURINI (1990a), when describing the basal conglomerates and breccias below the Auernig Formation (= Bombaso Formation), introduced the term "Pramollo Member" as part of the "Bombaso Formation". However, the type section of the "Pramollo Member" of the "Bombaso Formation" at the southern foothill of Auernig Mountain in fact represents sediments of the pre-Variscan Hochwipfel Formation. They are not equivalent to the basal conglomerates and breccias at Lake Zollner.

**Lithology:** Up to 20 m thick lydite breccias and conglomerates which are clast-supported in the lower and matrix-supported in the upper part.

**Fossils:** The coarse breccia and conglomerate contain no fossils except at the transition to the overlying pebble-bearing beds where some crinoids and gastropods occur.

**Origin, facies:** According to KRÄINER (1992) and VENTURINI (1990a, b) these rocks are interpreted as alluvial fan deposits at the transition to an offshore beach environment.

**Chronostratigraphic age:** Since direct fossil evidence is missing, the age can only be inferred from conodonts and fusulinids occurring in the overlying beds. They indicate an equivalent of the lower Kasimovian Stage (FORKE & SAMKASSOU, 2000; SCHÖNLAUB & FORKE, 2007). At locality Tomritsch in the basal deposits also plants of Cantabrian age occur suggesting an overall late Moscovian to early Kasimovian age for the formation of the Waidegg Formation (Collendiaul Formation).

**Biostratigraphy:** In the basal Auernig Fm. fusulinids (*Protriticites permirus*, *Beedeina asiatica*) and conodonts (*Idiog-nathodus* cf. *expansus*, *Swadelina*? aff. *makhlinae*) indicate lower Kasimovian.

**Thickness:** Approximately 20 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bischofalm and Zollner Formations (Silurian to Devonian). An unconformity separates the post-Variscan Waidegg Formation from the underlying pre-Variscan basement (FENNINGER et al., 1976; SCHÖNLAUB, 1985a).

**Overlying unit(s):** Auernig Formation.

**Lateral unit(s):** Malinfier Formation (VENTURINI, 1982) and Auernigalm Limestone Breccia (VENTURINI 1990a, b; SCHÖNLAUB & FORKE, 2005) (both not indicated in the ASC 2004).

**Geographic distribution:** Carnic Alps, Naßfeld and Zollner region across the Austrian/Italian border.

**Remarks:** -

**Complementary references:** -

### Auernig-Gruppe / Auernig Group

HANS P. SCHÖNLAUB

**Validity:** Invalid; the name "Auernigschichten" was introduced by FRECH (1894b).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld and 3110 Kötschach-Mauthen (ÖK50-BMN, map sheets 197 Kötschach, 198 Weißbrach), central Carnic Alps extending on both sides of the state border between Garnitzen gorge, Naßfeld and Lake Zollner.

**Type section:** No continuous section is known through the whole succession. FORKE et al. (2006) proposed for the lower parts the "Waschbühel" ridge in the vicinity of the Waidegger Alm (N 46°35'39" / E 13°07'02"), for the middle parts the Naßfeld region above the Watschiger Alm, and for its upper parts the ridge from Gugga to Garnitzen south of Watschiger Alm (N 46°33'37" / E 13°17'53") as type sections.

**Reference section(s):** -

**Derivation of name:** Mountain Auernig (1,863 m) south of Naßfeld Pass, Carnic Alps. Auernig stems from the old slavik word “avornik” (German: Ahornberg; English: Acer Mountain).

**Synonyms:** Auernigschichten (FRECH, 1894b; HERITSCH et al., 1934); Gruppo dell’ Auernig (SELLI, 1963).

**Lithology:** The clastic-carbonate succession is composed of quartz conglomerates, cross-bedded sandstones, bioturbated siltstones, and bedded, massive or nodular limestones.

The up to 20 m thick conglomerates have a grain- or matrix-supported fabric. Individual pebbles reach sizes of 10 cm and are composed predominantly of quartz and minor lydite embedded in a matrix of quartz and mica.

Sand-, siltstone and shale beds (6–50 m) show common cross-bedding and syndimentary slumping structures. Intercalated shales and siltstones may yield abundant plant debris, large concretions, and are commonly bioturbated. Some of the siltstones are rich in fossils, especially brachiopods. Accessory minerals like tourmaline, zircon, brookite/leukoxen and chloritoid point to plutonic and weakly metamorphosed source rocks for the clastic sediments (FENNINGER & STATTEGGER, 1977; MADER & NEUBAUER, 2004; MADER et al., 2007).

Bedded limestones contain diverse fossil remains (foraminifers, brachiopods, calcareous algae), whereas the indistinctly bedded and massive limestones are composed mainly of calcareous algae in a micritic-peloidal matrix forming mounds. Nodular limestones may occur above the bedded and massive limestones, characterized by their black color, marly interlayers, and accumulation of bryozoans, brachiopods and a silicified microfauna.

**Fossils:** Fusulinids, smaller foraminifers, conodonts, calcareous algae, corals, coralline sponges (*Sphinctozoa*), ostracods, bryozoans, brachiopods, trilobites, echinoderms, radiolarians, megaplants and trace fossils.

**Origin, facies:** The existence of Late Paleozoic depositional cycles has already been recognized in the 19<sup>th</sup> century by repetitive alternations of marine carbonates and siliciclastics with rocks bearing fossil megaplants. The transgressive-regressive pattern has been termed “Auernig rhythm” by KAHLER (1955). More recently, several authors favored a cyclothem model and glacio-eustasy to explain this pattern (MASSARI & VENTURINI, 1990; MASSARI et al., 1991; VENTURINI, 1990a, b, 1991; KRAINER, 1991, 1992; SAMANKASSOU, 1997).

Cyclothem are 10–30 m thick. Different types occur. The lithologies show rapid changes and the sequences exhibit clear transgressive (fining-upward) and regressive (coarsening-upward) tendencies.

The duration of one cyclothem is estimated to be ca. 40 ky by MASSARI & VENTURINI (1990), whereas KRAINER (1992) proposed 100 ky per cyclothem. As no continuous section of the entire succession is exposed and the biostratigraphic resolution by fusulinids is well above the cyclothem duration, uncertainties remain as to the duration. However, the high number of cyclothem in a short period of time favors a glacio-eustatic origin, similar to those of the North American Midcontinent (SAMANKASSOU, 1997, 2002).

**Chronostratigraphic age:** Pennsylvanian (lower Kasimovian to Gzhelian).

**Biostratigraphy:** The biostratigraphy and correlation of the succession with other standard subdivisions is predominantly based on fusulinids (KAHLER & KAHLER, 1937, 1982; KAHLER, 1939, 1962, 1983a, b, 1985, 1986a, b, 1992; PASINI, 1963; FORKE et al., 1998; KRAINER & DAVYDOV, 1998; DAVYDOV & KRAINER, 1999), partly in combination with conodonts (FORKE, 1995a, 2002; FORKE & SAMANKASSOU, 2000). Brachiopods, trilobites and ostracods have further been used for biostratigraphic purposes (GAURI, 1965; HAHN & HAHN, 1987; FOHRER, 1991, 1997). Floral remains provide an important contribution for correlation with coeval West and East European deposits (FRITZ & BOERSMA, 1986a, b; FRITZ et al., 1990).

Based on the combined use of conodont and fusulinid faunas and the comparison with faunas from the Cantabrian Mts., Moscow and Donets Basins FORKE & SAMANKASSOU (2000) concluded that the oldest fossiliferous beds of the succession correlate biostratigraphically with the lower Kasimovian (Krevyakinian) although its base is apparently diachronous at different localities.

The upper part of the succession [“Watschiger” Mb., Krone (Corona) Mb., Gugga Mb., Garnitzen (Carnizza) Mb. in the sense of FORKE et al. (2006)] represents a continuous sequence of approximately 400 m thickness. It starts probably during the *Jigulites jigulensis* fusulinid zone (Pavlovoposadian) and ranges throughout the *Daixina sokensis* fusulinid zone (Noginskian) (KRAINER & DAVYDOV, 1998; FORKE, 2007).

**Thickness:** The composite section reaches a thickness of about 800 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** In successive order the following formations were proposed by SELLI (1963) which, however, according to FORKE et al. (2006) and SCHÖNLAUB & FORKE (2007) must be regarded as Members: Meledis, Pizzul, Corona, Auernig and Carnizza. These members grossly correspond to the lithostratigraphic subdivision of HERITSCH et al. (1934).

**Underlying unit(s):** Waidegg Formation (now renamed in Collendiaul Formation).

**Overlying unit(s):** Lower Pseudoschwagerina Formation (recte: Schulterkofel Formation).

**Lateral unit(s):** No lateral transition into other units is known.

**Geographic distribution:** Carnic Alps of Austria and Italy, Karavanke Mountains of Austria and Slovenia.

**Remarks:** HERITSCH et al. (1934) lithologically defined and subdivided the “Auernigschichten” according to the predominance of limestone horizons into five units (“untere kalkarme, untere kalkreiche, mittlere kalkarme, obere kalkreiche, obere kalkarme Schichtgruppe”). A type section for the lower two units has been chosen along the “Waschbüchel” ridge in the vicinity of the Waidegger Alm. The upper part of the second unit (“untere kalkreiche Schichtgruppe”) was defined as “Watschiger Schichten” with the type locality above the Watschiger Alm. The upper three units have their type section along the mountain ridge from Gugga to Garnitzen.

SELLI (1963) introduced in his description of the five formations of the Auernig Group the terms Meledis, Pizzul, Corona, Auernig and Carnizza, which are regarded as equivalents to those of HERITSCH et al. (1934). To avoid further

confusion between the terms “Auernig Formation” sensu SELLI (1963) and the term “Auernig Formation” used herein, the term “Gugga Member” was proposed by SCHÖNLAUB & FORKE (2007) as analogous replacement for the “obere kalkreiche Schichtgruppe” sensu HERITSCH et al. (1934). The Trögl-Creta di Rio Secco Member was introduced by FORKE et al. (2006) to describe a carbonate succession at Rosskofel (Monte Cavallo), directly overlying folded Devonian–lower Carboniferous limestones.

VENTURINI (1990) and VAI & VENTURINI (1997) proposed a revised stratigraphic subdivision of the upper Carboniferous clastic/carbonate succession of the Auernig Group, consisting of five formations and excluded the basal breccias and conglomerates as Bombaso Formation (Waidegg Formation in the ASC 2004 and Collendiaul Formation of SCHÖNLAUB & FORKE, 2005, respectively). This scheme was adopted by most following authors (KRAINER, 1990a, 1991, 1992, 1995; KRAINER & DAVYDOV, 1998; DAVYDOV & KRAINER, 1999).

However, due to the strong faulting and complex tectonics it is often difficult to find sections allowing a definition of the base and top of stratigraphic units. Up to now, a complete succession with composite sections has never been reconstructed, individual sections have neither lithologically, nor faunistically been successfully correlated, and a definition of stratigraphic units after the “Recommendations (guidelines) of the usage of stratigraphic nomenclature” (STEININGER & PILLER, 1999) has never been undertaken.

Furthermore, the proposed stratigraphic subdivision of the “Auernig Group” into formations would require distinguishing the formations as mappable units in the field. However, the formations are neither traceable for longer distances, nor presentable in geological maps.

There are several reasons to keep the upper Carboniferous succession as Auernig Formation and to give informal names for the different investigated sections:

1. The “untere kalkreiche Schichtgruppe” (or the equivalent “Pizzul Formation”) consists of two parts (Waschbühel Schichten and Watschiger Schichten), which have never been successfully correlated. Moreover, the base of the formation has never been defined after the revision of FENNINGER et al. (1971). The alternatively proposed type section (after the locality Monte Pizzul) is neither lithologically, nor biostratigraphically sufficiently investigated for correlation.

2. The “untere kalkarme Schichtgruppe” (or the equivalent “Meledis Formation”) in its original type section (Waschbühel ridge) is composed of two units bounded by tectonic contacts. Biostratigraphic data are available only from the northern (“lower”) part (so-called “Waidegger Fauna” of HERITSCH et al., 1934; METZ, 1936; GAURI, 1965). In the alternatively proposed type section (section Rio Cordin east of the Casera Meledis) the base of the formation is not exposed and the succession is overlain directly by the Middle Permian Gröden Formation. Moreover, KRAINER & DAVYDOV (1998) described an “early Gzhelian” (more probably late Kasimovian) fauna from this section, although the overlying (?) Pizzul Formation is partly older (middle-late Kasimovian fauna of the Waschbühel ridge).

**Complementary references:** -

## Untere Pseudoschwagerinen-Formation / Lower Pseudoschwagerina Formation

[recte: Schulterkofel-Formation / Schulterkofel Formation (KRAINER, 1995)]

HANS P. SCHÖNLAUB

**Validity:** First denomination by KAHLER (1947) and later formalized by KRAINER (1995) who renamed the former Lower Pseudoschwagerina Limestone following international recommendations into Schulterkofel Formation (= valid).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** The lower boundary and main part of the Schulterkofel Formation is exposed at the section along the northwestern edge of the cliff of the Mountain Schulterkofel (N 46°35'24" / E 13°10'09").

Remarks: The upper boundary of the Schulterkofel Formation and transition to the basal Grenzland Formation is best exposed above the trail from Rattendorfer Schneid to Cordin Alm in a section forming peak 1,997 m ranging from the base of the cliff to south of peak 1,997 m.

**Reference section(s):** -

**Derivation of name:** After the genus *Pseudoschwagerina*, a fusulinid foraminifer.

**Synonyms:** Unterer Schwagerinenkalk (HERITSCH et al., 1934: p. 176); Unterer Pseudoschwagerinenkalk (KAHLER, 1947: p. 61); untere Pseudoschwagerinen Schichten (E. FLÜGEL, 1975); untere Pseudoschwagerinen-Formation (SCHÖNLAUB et al., 1988).

Remarks: Due to changes in the fusulinid systematics, KAHLER (1947) changed the original Lower Schwagerina Lst. of HERITSCH et al. (1934) to Lower Pseudoschwagerina Lst. However, since the genus *Pseudoschwagerina* is missing in this section, KRAINER (1995) recommended a change of the name according to the international usage of lithostratigraphic nomenclature.

**Lithology:** The Lower Pseudoschwagerina Formation (Schulterkofel Formation) is predominantly a carbonate succession with subordinate fine sand- and siltstones. Siliciclastic beds are often intercalated with fossiliferous horizons, grading from calcareous sandstones to sandy limestones with tempestitic beds, rich in smaller foraminifers, echinoderm fragments, brachiopods and gastropods.

Massive limestones form up to 20 m high, almost monospecific (*Anthracoporella spectabilis*) mounds with a sparse associated fauna of rare smaller foraminifers, ostracods and gastropods embedded in a micritic-peloidal matrix. Medium- to thick-bedded limestones occur at the base and in between individual mounds composed of a higher diverse fauna with foraminifers, phylloid algae and others.

Mounds and bedded limestones are overlain by dark, nodular limestones (partly with shale interlayers) with chert nodules containing thick-shelled brachiopods, cephalopods and solitary corals.

**Fossils:** Fusulinids, smaller foraminifers, phylloid algae, dasycladacean algae (*Anthracoporella*), microproblematica (*Tubiphytes*).

**Origin, facies:** Siliciclastics at the base represent shoreface deposits. Bedded and massive limestones occur below the storm wave base, but within the photic zone during

the transgressive phase of the Lower Pseudoschwagerina Formation cyclic limestone sequence (SAMANKASSOU, 1997). Thick mounds, resulting from increased accommodation space, indicate that mounds kept pace with sea-level. Mound growth was terminated by drowning through sea-level rise (SAMANKASSOU, 1999). Bedded, bio- and lithoclastic limestones on top of the cycles indicate forced regression and erosion of the underlying dark limestones.

The Lower Pseudoschwagerina Formation, representing about one fusulinid zone (*bosbytauensis-robusta* Zone), is composed of four cyclothems (HOMANN, 1969; SAMANKASSOU, 1997). The mean duration of one fusulinid zone is estimated as 1–1.5 ma (ROSS & ROSS, 1995), implying a mean duration of 300 to 400 ka for each single cyclothem.

**Chronostratigraphic age:** Uppermost Gzhelian.

**Biostratigraphy:** The index fossil *Daixina* (*Bosbytauella*) *postgallowayi* (= ex *Occidentoschwagerina alpina* KAHLER & KAHLER, 1941, megalospheric form) is the diagnostic species of the *bosbytauensis-robusta* Zone, but is not present throughout the section. The lowermost part yields species of *Ruzhenzevites*, *Dutkevitchia* (known also from the underlying Auernig Group), and the *Schwageriniformis perstabilis* group. Species of the *Rugosofusulina stabilis* group and of *Rugosochusenella* have their first appearance in the middle and upper part of the section, which is primarily characterized by the occurrence of the highly inflated species of the genus *Daixina* (subgenus *Bosbytauella*). In the uppermost part *Daixina* (*Bosbytauella*) disappears and is replaced by species of *Schwagerina* and *Dutkevitchites* in the topmost layers.

The lowermost assemblage of the Lower Pseudoschwagerina Formation may still belong to the *Daixina sokensis* Zone, whereas the main part of the sequence can certainly be correlated with the *bosbytauensis-robusta* Zone. The base of the following *vulgaris-fusififormis* Zone cannot be precisely correlated, as a fusulinoid assemblage with intermediate characteristics occurs in the topmost layers of the Lower Pseudoschwagerina Formation. Therefore, the boundary between the Carboniferous and Permian systems, defined by the First Appearance Datum (FAD) of *Streptognathodus isolatus* (approximately coinciding with the base of the *vulgaris-fusififormis* Zone) is slightly vague in the Carnic Alps, and spans an inferred interval from the topmost layers of the Schulterkofel Formation to the basal limestone beds of the Grenzland Formation.

**Thickness:** The thickness in the type section is 136 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Auernig Formation.

**Overlying unit(s):** Grenzland Formation.

**Lateral unit(s):** The more than 130 m thick type section decreases in thickness laterally within rather short distances of some 2 km at Pian di Lanza (Lanzenboden) to less than 60 m.

**Geographic distribution:** Carnic Alps, mainly west of Naßfeld crossing the Austrian/Italian border (Schulterkofel, Ringmauer, Pian di Lanza, Rudnigalm, Tressdorfer Höhe, Garnitzenalm).

**Remarks:** In the ASC 2004 the old lithostratigraphic term “Lower Pseudoschwagerina Formation” was printed by a regrettable mistake in place of the term Schulterkofel For-

mation. KRAINER (1995: p. 689) already formalized and renamed the unit in Schulterkofel Formation after the mountain Schulterkofel (2,091 m; Italian name: Creta di Lanza) in the central Carnic Alps west of Rattendorfer Alm.

Italian name of the Schulterkofel Formation: Creta di Lanza Formation.

**Complementary references:** SCHÖNLAUB & FORKE (2007)

## Grenzland-Formation / Grenzland Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; first denomination as “Grenzlandbänke” by HERITSCH et al. (1934: p. 178).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** Not yet designated.

Remarks: No complete section of the Grenzland Formation exists. The base is exposed below peak 1,997 m (see Lower Pseudoschwagerina Formation/Schulterkofel Formation). The lower part of the Grenzland Formation is exposed along the border between Austria and Italy south of Rattendorfer Alm. The top of the Grenzland Formation and transition to the overlying Zweikofel Formation is located in the ravine between the mountains Zweikofel (peak 2,059 m) and Zuckerhütl (2,034 m).

**Reference section(s):** -

**Derivation of name:** Name expresses the location of the section along the state border between Austria and Italy.

**Synonyms:** Grenzlandbänke (“Grenzland Beds”) (HERITSCH et al., 1934: p. 178).

**Lithology:** Clastic marine sequence characterized by oncolithic limestone intercalations containing large (0.5–1 cm) spherical fusulinids. Quartz conglomerates are less common and comparably thinner than in the Auernig Group. More common are thick calcareous sandstones with quartz grains exhibiting dissolution features on top with brecciation and dissolved fossil remains, often filled with a red matrix. Siltstones display common bioturbation and sediment structures (slumping, convolute bedding and load casts), as well as ichnofossils (*Zoophycos*).

In addition to the oncoidal limestones, bioclastic limestones with a diverse fauna, as well as reddish limestones with dissolution features and brecciation occur in the Grenzland Formation.

**Fossils:** Fusulinids, smaller foraminifers, ostracods, crinoids, bryozoans, brachiopods, phylloid algae, dasycladacean algae (*Epimastopora*), oncoids, trace fossils, microproblematica (*Ramovsia*, *Tubiphytes*) and megaplants (FRITZ & KRAINER, 2004).

**Origin, facies:** Provenance analysis of the clastics indicates magmatic and metamorphic source areas (TIETZ, 1974; MADER & NEUBAUER, 2004). Microfacies of the limestones points to high-energy nearshore deposits (E. FLÜGEL, 1975).

The Grenzland Formation is likewise characterized by cyclic deposits. Individual cycles of up to 10 m thickness with conglomerates and sandstones at the base, overlain by transitional clastic-carbonate deposits with a diverse fauna are followed by oncoidal limestones.

Paleosols, fracture fillings and collapse breccia occur within sections exposed at mountain Zweikofel, proofing intervals of subaerial exposure (VENTURINI, 1990a, b; SAMANKASSOU, 1997).

**Chronostratigraphic age:** Originally correlated to the middle Asselian, the Grenzland Fm. seems to represent the entire Asselian plus part of the Sakmarian (FORKE, 2002). In comparison with the much thicker Auernig Group, however, non-deposition and erosion have to be considered in this sequence suggesting a much longer time interval although clear sedimentological hints have not been found yet.

**Biostratigraphy:** To date, limestone beds with fusulinids have been investigated only in the lower and uppermost parts of the Grenzland Formation. Based on the occurrence of *Sphaeroschwagerina carniolica* and *Pseudoschwagerina extensa* the faunal assemblages of the lower part indicate an early? to middle Asselian age. The upper part yields *Sphaeroschwagerina asiatica*, i.e., a species of the *Paraschwagerina nitida* group, and first primitive *Zellia* and *Robustoschwagerina*, indicating a Sakmarian age (FORKE, 2002).

**Thickness:** As no continuous section exists, the maximum thickness is estimated at about 120 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lower Pseudoschwagerina Formation (Schulterkofel Formation).

**Overlying unit(s):** Upper Pseudoschwagerina Formation (Zweikofel Formation).

**Lateral unit(s):** -

**Geographic distribution:** Carnic Alps, mainly west of Naßfeld crossing the Austrian/Italian border (Schulterkofel, Ringmauer, Rattendorfer Schneid, Pian di Lanza, Rudnigalm, north of Kühweger Alm).

**Remarks:** Italian name of the Grenzland Formation: Val Dolce Formation

**Complementary references:** -

#### **Obere Pseudoschwagerinen-Formation / Upper Pseudoschwagerina Formation**

[recte: Zweikofel-Formation / Zweikofel Formation  
(KRAINER, 1995)]

HANS P. SCHÖNLAUB

**Validity:** First denomination by KAHLER (1947) and later formalized by KRAINER (1995: p. 689) who renamed the former Upper *Pseudoschwagerina* Limestone following international recommendations.

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia (N 46°34'47" / E 13°13'12").

**Type section:** Originally the section at Zottachkopf was chosen as type section by HERITSCH et al. (1934). However, at this section only less than half of the succession is exposed.

**Reference section(s):** Complete sections occur on the western part of Zweikofel and in the upper Garnitzen gorge.

**Derivation of name:** After the genus *Pseudoschwagerina*, a fusulinid foraminifer.

**Synonyms:** Oberer Schwagerinenkalk (HERITSCH et al., 1934: p. 178); oberer Pseudoschwagerinenkalk (KAHLER, 1947); obere Pseudoschwagerinen Schichten (E. FLÜGEL, 1975); obere Pseudoschwagerinen-Formation (SCHÖNLAUB et al., 1988).

**Remarks:** Due to changes in the fusulinid taxonomy, KAHLER (1947) changed the original Upper Schwagerina Lst. of HERITSCH et al. (1934) to Upper Pseudoschwagerina Lst. However, since the genus *Pseudoschwagerina* is missing in this section, KRAINER (1995) recommended a change of the name according to the international usage of lithostratigraphic nomenclature.

**Lithology:** The Zweikofel Formation is mainly composed of carbonates characterized by bedded, oncoidal and foraminifer-algal limestones. Small, highly diverse mounds, reddish, bioclastic crinoidal limestones and oolites are present in the lower part. Siliciclastic input with quartz pebbles and sandstone lenses is restricted to northwestern areas.

**Fossils:** Fusulinids (*Zellia*, *Robustoschwagerina*, *Paraschwagerina*, "*Pseudofusulina*", *Pseudochusenella*), smaller foraminifers, conodonts (*Sweetognathus* aff. *whitei*, *Diplognathodus*, *Mesogondolella bisselli*), crinoids, bryozoans, corals, brachiopods, phylloid algae, dasycladacean algae (*Epimastopora*), microproblematica (*Tubiphytes*).

**Origin, facies:** Siliciclastics retreat in the Zweikofel Formation and a complex carbonate platform developed with high-energy ooid bars (Zweikofel area), subtidal, oncoid limestones (Zottachkopf area) and small mounds (Troglkar area). Variations in microfacies, biotic associations and geochemical composition have been pointed out by E. FLÜGEL (1975). The lateral variations in cyclic patterns could be explained by a differentiated shelf and sea-bottom morphology at time of deposition. High-frequent sea-level fluctuations are superposed on these morphological variations (SAMANKASSOU, 1997).

**Chronostratigraphic age:** According to FORKE (1995b, c, 2002) the Zweikofel Formation has a late Sakmarian to early Artinskian age.

**Remarks:** Due to the three-fold subdivision of the Asselian (lower-middle-upper) and the disappearance of "inflated schwagerinids" at the beginning of the Sakmarian in the type sections of the Urals, the Zweikofel Formation has long been correlated with the upper Asselian by KAHLER (1986a).

According to FORKE (1995a, b, 2002) geographic barriers and/or changes in the oceanographic circulation pattern are responsible for the impoverished fusulinoidean faunas of the Urals. The co-occurrence of "inflated schwagerinids" with Sakmarian/Artinskian conodonts has demonstrated that these groups have much longer stratigraphic ranges in the Tethyan faunal realm.

**Biostratigraphy:** Based on fusulinids and conodonts.

**Thickness:** Maximum thickness in the Zweikofel type section is 135 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Grenzland Formation.

**Overlying unit(s):** Troglkar Limestone.

**Lateral unit(s):** See above in chapter “Origin, facies”.

**Geographic distribution:** Carnic Alps, west and northeast of Naßfeld (Zweikofel Massif, Zottachkopf, Rudnig Kar, Rudnigalm, Reppwand, upper Garnitzen gorge).

**Remarks:** In the ASC 2004 the old lithostratigraphic term “Upper Pseudoschwagerina Formation” was printed by a mistake in place of the term Zweikofel Formation. KRAINER (1995: p. 689) already formalized and renamed the unit in Zweikofel Formation after the mountain Zweikofel (2,059 m) between Rattendorfer and Rudnig Alm.

**Complementary references:** SCHÖNLAUB & FORKE (2007).

### Trogkofelkalk / Trogkofel Limestone

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by GEYER (1898: p. 252) to designate this limestone complex as an equivalent of the Permian Artinskian Stage and not as Triassic as suggested previously by FRECH (1894b).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** Not defined.

**Reference section(s):** -

Remarks: The section at the Trogkofel mountain (2,280 m) along the Überlacher trail (N 46°34'10" / E 13°13'05") or at the westernmost edge of the steep cliff may serve as type section in the future. Additional sections are exposed at the Reppwand cliff and in the upper Garnitzen gorge.

**Derivation of name:** After the mountain Trogkofel (2,280 m) between Rattendorfer and Rudnig Alm.

**Synonyms:** Trogkofel Schichten (SCHELLWIEN, 1898: p. 279).

**Lithology:** The Trogkofel Limestone is mainly composed of massive, light-colored, partly reddish carbonates. Large parts correspond to a *Tubiphytes/Archaeolithoporella*-cement boundstone. Dolomitization is common and ranges from isolated euhedral dolomitic rhombs to a complete replacement. Boundstones may occur as clasts and boulders, probably representing syndimentary breccias. Indistinctly bedded, well preserved dasycladacean grainstones with a spotty distribution of fusulinids can be found in the upper part of the Trogkofel Mountain along the Überlacher trail. The bedded, ruditic limestones with shale intercalations represent an exceptional lithofacies in the Zweikofel section.

**Fossils:** Fusulinids, smaller foraminifers, conodonts, crinoids, bryozoans, corals, sponges, dasycladacean algae, microproblematica (*Tubiphytes*, *Archaeolithoporella*).

**Origin, facies:** The Trogkofel Limestone includes reefs that differ from those of the previous formations as being interpreted as shelf margin reefs (FLÜGEL, 1981). These types are the thickest reefs of the Upper Paleozoic sequence in the Carnic Alps. They are characterized by the interaction of encrusting organisms (algae, sponges, bryozoans) and syndimentary cementation, supported by microbial and algal activities forming an organic framework. Other lithofacies types within the Trogkofel Limestone point to platform sediments (limestones with dasycladaceans and fusulinids) and upper slope (breccias) deposits. No detailed reconstruction of the stratal patterns in the Trogkofel Lime-

stone has been elaborated so far. However, similar platform – reef – slope geometries are known from carbonate platform systems in northwestern Spain (BAHAMONDE et al., 2000), which may serve as a model for the Trogkofel Limestone.

**Chronostratigraphic age:** Late Artinskian.

**Biostratigraphy:** Rare occurrences of *Robustoschwagerina spatiosa* together with a single conodont taxon (*Neostreptognathodus* cf. *pequopensis*) from the ruditic limestones indicate upper Artinskian for the Trogkofel Limestone.

**Thickness:** Maximum thickness at Trogkofel approx. 400 m, at Reppwand and Garnitzen gorge 200 to 300 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Upper Pseudoschwagerina Formation (Zweikofel Formation).

**Overlying unit(s):** Trogkofel Conglomerate (not indicated in the ASC 2004), Tarvis Breccia, Gröden Formation.

**Lateral unit(s):** The locally occurring Tressdorf Limestone in the Naßfeld area (a polymict limestone breccia) and the Goggau Limestone occurring along the old road from Tarvisio to the village Goggau (KAHLER & KAHLER, 1980) and in the western Karavanke mountains of Slovenia (pers. comm. FORKE and NOVAK) may represent lateral equivalents of the Trogkofel Limestone.

**Geographic distribution:** Carnic Alps (Trogkofel, Zweikofel Massif, Rudnigalm, Reppwand, upper Garnitzen gorge, northeast slope of Col Mezzodi near Forni Avoltri). At the latter locality the boundary between the Zweikofel Formation and the overlying Trogkofel Limestone is not precisely known yet), Karavanke Mountains, Slovenia.

**Remarks:** -

**Complementary references:** -

### Treßdorfer Kalk / Treßdorf Limestone

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by HOMANN (1969: p. 278) to designate isolated occurrences of polymict limestone breccias in the surroundings of the Treßdorf Alm northeast of Naßfeld.

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** No reference section exists since the main occurrence WNW of Treßdorf Alm is only some meters in thickness (N 46°34'42" / E 13°15'28").

**Reference section(s):** -

**Derivation of name:** After Treßdorf Alm located closely to this limestone unit (see SCHÖNLAUB & FORKE, 2007).

**Synonyms:** -

**Lithology:** According to HOMANN (1969) and FLÜGEL (1968) the Treßdorf Limestone represents a clast-supported stylonbreccia. The cm-sized angular and subrounded clasts reflect different types of microfacies which are supposedly derived from the Trogkofel Limestone and the underlying Zweikofel Formation. The majority of the clasts are light-greyish *Tubiphytes-Archaeolithoporella*-cement boundstones and thus resemble the typical Trogkofel Limestone

while others are oosparites and biosparites with fusulinids, echinoderms and microproblematica (*Tubiphytes*, *Epi-mastopora*). Some others are massive indistinct limestone clasts not known from the Trogkofel Limestone.

**Fossils:** In the limestone clasts fusulinids, smaller foraminifers, crinoids, bryozoans, corals, sponges, ostracods and microproblematica (*Tubiphytes*, *Archaeolithoporella*, *Epi-mastopora*) were identified.

**Origin, facies:** The origin of the Treßdorf Limestone is yet not fully understood. It either represents a lateral equivalent of the Trogkofel Limestone or reworked Trogkofel and Zweikofel Limestones formed at a later stage.

**Chronostratigraphic age:** Based on the fusulinids in the breccias KÄHLER & KÄHLER (1980) concluded an Artinskian age for the Treßdorf Limestone. In addition, they pointed out that this limestone is much younger than the Trogkofel Limestone near Forni Avoltri.

**Biostratigraphy:** Fusulinids, i.e., representatives of *Pseudofusulina* and *Praeparafusulina* in the clasts of the Treßdorf Limestone were identified by KÄHLER & KÄHLER (1980) and partly revised by FORKE (1995b, c, 2002).

**Thickness:** Maximum thickness is less than 10 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Trogkofel Limestone (?).

**Overlying unit(s):** Trogkofel Conglomerate (not indicated in the ASC 2004), Tarvis Breccia, Gröden Formation.

**Lateral unit(s):** It has been suggested that the more than 120 m thick Coccau/Goggau Limestone occurring along the old road from Tarvisio to the village of Coccau/Goggau is a lateral equivalent of the Treßdorf Limestone. However, in the Coccau/Goggau Lst. a more diversified fusulinid fauna occurs which is slightly different from the one in the Treßdorf Limestone suggesting different ages of both limestones. Apparently coeval limestones occur in the western Karavanke mountains of Slovenia.

**Geographic distribution:** Carnic Alps in the vicinity of Treßdorf Alm and close to Coccau/Goggau near Tarvisio (Italy).

**Remarks:** -

**Complementary references:** -

### Tarviser Brekzie / Tarvis Breccia

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by HERITSCH (1928b) to designate a breccia horizon at the road near Coccau/Goggau half distance between the Austrian/Italian border and Tarvisio (Italy).

**Type area:** Vicinity of the village Coccau/Goggau, Carta Geologica d'Italia 1:100.000, F° 14<sup>A</sup> Tarvisio (1968). ÖK50-UTM, map sheet 3117 Nötsch im Gailtal (ÖK50-BMN, map sheet 200 Arnoldstein).

**Type section:** Outcrop at the road near Coccau/Goggau (Italy) southeast of the church of Upper Coccau (N 46°30'49" / E 13°36'41") (BUGGISCH & FLÜGEL, 1980).

**Reference section(s):** According to FORKE (pers. comm.) better outcrops are located near Forni Avoltri (Italy) and in Dovzanova soteska (Slovenia).

**Derivation of name:** After the city of Tarvisio (German: Tarvis) in the Regione Autonoma Friuli-Venezia Giulia, Italia.

**Synonyms:** Breccia di Tarvisio, Conglomerato di Sesto (Sexten-Konglomerat) (BUGGISCH et al., 1976; BUGGISCH & FLÜGEL, 1980; SCHÖNLAUB & FORKE, 2007).

**Lithology:** The Tarvis Breccia east of Straniger Alm consists of a 10 m thick succession of massive dolomite, Rauhwaacke, interbedded red siltstones and greyish dolomitic breccias. It thus contrasts with the Trogkofel Breccia which is composed of carbonate clasts (reworked Trogkofel Limestone) with a negligible amount of siliciclastics (BUGGISCH et al., 1976). Such clasts have diameters of 2 to 8 cm and are cemented either in a fine-grained dolomitic matrix or a grey massive homogenous one.

**Fossils:** The breccia does not contain any fossils.

**Origin, facies:** The breccia was formed during tectonic uplift of the Lower Permian succession under karstic conditions resulting from an arid environment. Synsedimentary faults have aided the formation of mainly subaerial fan deposits of strongly varying thickness intergrading with the base of the Gröden Formation.

**Chronostratigraphic age:** The age of the Tarvis Breccia can only indirectly be inferred from the underlying fossiliferous Trogkofel Lst. indicating a late Artinskian age and the "Illawara Reversal-Event" identified some 170 m above the base of the overlying Gröden (Val Gardena) Formation near Paularo and also in the Dolomites (MAURITSCH & BECKE, 1983; DACHROTH, 1988). According to MENNING (2001) this event occurred 265 Ma ago in the uppermost Wordian Stage (Middle Permian). The formation of the breccias can thus be attributed to a time interval between the end of the Artinskian and the beginning of the Wordian.

**Biostratigraphy:** -

**Thickness:** Maximum thickness is some 10 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** In the area between Straniger Alm and Passo del Cason di Lanza the Tarvis Breccia rests unconformably on the Auernig Formation, north of Gartnerkofel (Reppwand), however, on Trogkofel Limestone.

**Overlying unit(s):** Gröden (Val Gardena) Formation.

**Lateral unit(s):** Conglomerato di Sesto (Sexten-Kalkbrekzie) in the westernmost Carnic Alps (FLÜGEL & KRAUS, 1988; SCHÖNLAUB, 2000c).

**Geographic distribution:** Carnic Alps of northern Italy and southern Austria (Naßfeld area, surroundings of Straniger Alm and Passo del Cason di Lanza, west of mountain Seikofel near Sexten).

**Remarks:** A summary of the various breccia horizons at the base of the Gröden Formation was published by BUGGISCH et al. (1976) and BUGGISCH & FLÜGEL (1980). In the Naßfeld area detailed sedimentological investigations to characterize the deposits according to their stratigraphy and genesis have not been carried out. All those deposits at the base of the Gröden Formation above the Auernig Group are herein described as "Tarvis Breccia" while those resting directly on the Trogkofel Limestone are named "Trogkofel Breccia" and "Trogkofel Conglomerate", respectively. However, these are neither mentioned in the ASC 2004, nor described herein.

**Complementary references:** -



## Gröden-Formation / Gröden Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by RICHTHOFEN (1860: p. 47) in the Dolomites of northern Italy.

**Type area:** Gröden Valley (Val Gardena) in the Dolomites.

**Type section:** No formally designated type section. Bletterbach near Aldein-Radein would be the best candidate (LEONARDI, 1949, 1967; BUGGISCH, 1978; CONTI et al., 1986; MASSARI et al., 1988).

**Reference section(s):** ÖK50-UTM, map sheet 3110 Kötschach-Mauthen (ÖK50-BMN, map sheet 197 Kötschach) near the small village of Lanz (1,038 m) NNE of Kötschach along the forest road from Lanz to Dellacher Alm and Riedgraben SW of the village of Paternion, respectively (KRAINER, 1990b).

**Derivation of name:** After the village of Gröden in the Gröden Valley, Italy.

**Synonyms:** Grödener Schichten, Gröden Sandstein, Griffener Schichten (cf. TOLLMANN, 1977; NIEDERMAYR & SCHERIAU-NIEDERMAYR, 1982; KRAINER 1985, 1987a).

**Lithology:** In the Naßfeld area the Gröden Formation is developed as marine clastic sediments with carbonatic intercalations (BUGGISCH, 1978). It is predominantly composed of a red, partly greenish-grey alternation of dolomitic mud- and siltstones. Intercalated are nodular dolomitic marls or dolomites. The transition into the overlying Bellerophon Formation is characterized by interbedded grey siltstones, red mudstones, and bituminous dolomite beds.

**Remarks:** The intensively red-colored pelites of the Gröden Formation are one of the most conspicuous lithologies in the Upper Paleozoic rock sequence. They disconformably overly various metamorphic rocks, as well as marine Upper Paleozoic deposits north and south of the Periadriatic Lineament. In the Southern Alps, the Gröden Formation may rest on lower Paleozoic rocks, on the upper Carboniferous Auernig Group, or on the Lower Permian Trogkofel Limestone. At the base of the Gröden Formation coarse breccias and conglomerates occur (Tarvis Breccia, Trogkofel Breccia) due to partial reworking of the underlying deposits.

**Fossils:** In the eastern Carnic Alps rare occurrences of stromatolites, smaller foraminifers, ostracods and gastropods.

**Origin, facies:** The depositional environment of the Gröden Fm. has been controversially discussed in the literature as either predominantly continental or mainly marine. BUGGISCH (1978) favored prevailing marine conditions from fossils and geochemical data. In the Naßfeld area at least short-term marine incursions can be inferred from the marine fauna and bioturbation. However, pedogenic concretions, hardpans and root traces hint to prolonged time of subaerial exposure (SCHÖNLAUB & FORKE, 2007).

**Chronostratigraphic age:** Generally, a late Middle Permian (Guadalupian) to early Late Permian (Lopingian) age can be inferred from the position between the underlying Trogkofel Limestone, an assumed prolonged interval of erosion and non-deposition and the more fossiliferous Bellerophon Formation above.

**Biostratigraphy:** For a precise correlation the available fossil data from the Dolomites, i.e., plants, tetrapod tracks, and rare cephalopods cannot be used. In addition,

in thin sections stromatolitic algae, smaller foraminifers, ostracods and gastropods were observed (BUGGISCH, 1978).

Magnetostratigraphy provides additional results for global correlation: The "Illawara Reversal-Event", which has been identified in the Paularo section (MAURITSCH & BECKE, 1983) as well as in the Dolomites (DACHROTH, 1988), is dated as 265 Ma (latest Wordian/Capitanian) by MENNING (2001).

**Thickness:** Ranging between 30 m in the Reppwand cliff and some 100 m northwest of Passo del Cason di Lanza.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Tarvis Breccia, Trogkofel Limestone or Auernig Group west of the Naßfeld area, lower Paleozoic strata or weakly metamorphosed rocks in the eastern Dolomites and western Carnic Alps, respectively.

**Overlying unit(s):** Bellerophon Formation.

**Lateral unit(s):** -

**Geographic distribution:** Carnic Alps of northern Italy and southern Austria (Naßfeld area, surroundings of Straniger Alm and Passo del Cason di Lanza, area surrounding mountain Seikofel east of Sexten in the western Carnic Alps).

**Remarks:** Italian name of the Gröden Formation: Val Gardena Formation.

**Complementary references:** SCHÖNLAUB & FORKE (2007).

## Bellerophon-Formation / Bellerophon Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by HOERNES (1876: p. 38–44).

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Austria.

**Type section:** Not defined.

**Reference section(s):** Eastern part of Reppwand cliff below "Sauboden".

**Derivation of name:** After the frequently occurring gastropod genus *Bellerophon* in this unit of the Dolomites.

**Synonyms:** Bellerophonschichten (HOERNES, 1876); Bellerophonkalk (HERITSCH et al., 1934); Bellerophondolomit (KAHLER & PREY, 1963).

**Lithology:** The lower part consists of dolomite, dolomitic marls and rauhacke, followed by platy to coarse bedded dolomitic grain- and mudstones. Grainstones yield abundant smaller foraminifers, dasycladacean algae and intraclasts. Mudstones contain mainly ostracods and radiolarians.

**Fossils:** Smaller foraminifers, dasycladacean algae, ostracods, radiolarians, gastropods and few conodonts.

**Origin, facies:** The sedimentary environment reflects an alternation of evaporitic and high-energy, open marine environments in the lower part and restricted, low-energy conditions in the upper part (BUGGISCH, 1975).

**Chronostratigraphic age:** Late Permian (late Wuchiapingian/late Dzhulfian to Changhsingian/Dorashamian).

**Biostratigraphy:** Smaller foraminifers are represented by a *Globivalvulina-Hemigordius* assemblage similar to the fauna in the adjacent western areas of the Southern Alps (BOECKELMANN, 1988; JENNY-DESHUSSES, 1991). Despite the absence of larger foraminifers, the presence of *Paraglobivalvulina* and *Paradagmarita* indicates Late Permian.

**Thickness:** The Bellerophon Formation has a measured thickness of 175 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Gröden Formation.

**Overlying unit(s):** Werfen Formation.

**Lateral unit(s):** The sections in the Carnic Alps suggest a stronger marine influx than in the Dolomites where bituminous limestones, rauhwackes, marls and gypsum layers dominate. This neritic-lagoonal facies was termed "Batiotic Facies" by ACCORDI (1959). In northern Slovenia similar lithologies like in the Carnic Alps occur which change towards east and west between open marine and lagoonal to evaporitic sequences (Zazar Formation).

**Geographic distribution:** In Austria the *Bellerophon* Formation occurs mainly in the Naßfeld and Gartnerkofel area.

**Remarks:** -

**Complementary references:** -

## Karawanken / Karavanke Mountains

### Pre-Variscan Sequence

Pre-Variscan sediments of the Karavanke Mountains are more or less constricted to occurrences at the Eisenkappel and Seeberg area (SIEWERT, 1984). Corresponding deeper marine sections are exposed within the Trögen area (MOSHAMMER, 1987). The units of the southern Karavanke Mountains, close to the Slovenian border (RAMOVŠ, 1999), show affinities to the Carnic Alps in their depositional development of mainly neritic to pelagic carbonates. Both regions are located south of the Periadriatic Lineament (BAUER, 1984; BAUER & SCHERMANN, 1984), which implies a similar palaeolatitudinal setting within the southern realm of the Rheic Ocean. The pre-Variscan sediments of the Karavanke Mountains (Text-Fig. 4) crop out within an area of about 25 km in W-E extension and 3.5 km in N-S extension. During the Ordovician mainly shallow marine sediments were deposited. During the Silurian to Middle Devonian times in the Seeberg area only pelagic limestones and deeper marine shales including tuffs occur. The environmental conditions changed to a shallow marine carbonate facies with reef complexes during the Middle and Late

Devonian. However, Mid-Devonian reefs are not as well developed as the Givetian reefs in the Carnic Alps. Subsequently, lower Carboniferous pelagic limestones and flysch sediments became the dominant facies which closely resembles the succession in the Carnic Alps.

### Schillkalke / Coquina Limestones

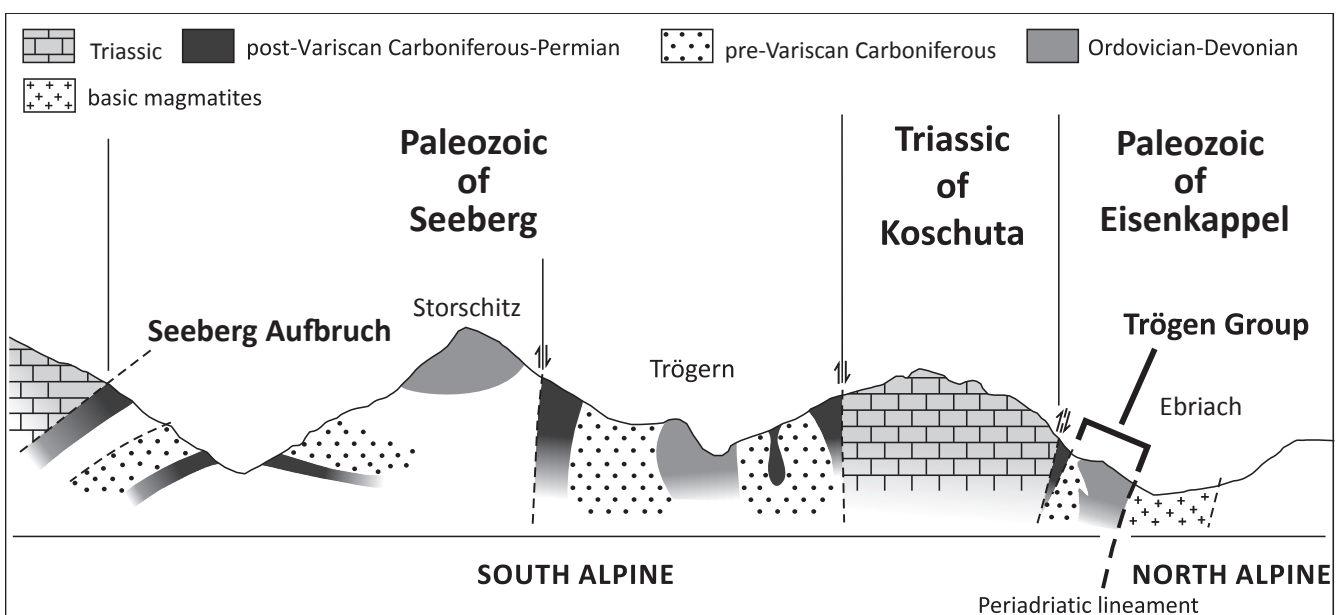
THOMAS J. SUTTNER

**Validity:** Invalid; described by KUPSCH et al. (1971); biostratigraphy by MOSHAMMER (1989).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Feistritzgraben (SCHÖNLAUB, 1979); Trögen Klamm section-group A (MOSHAMMER, 1989, 1990), N 46°28'04" / E 14°30'28".



Text-Fig. 4.  
Simplified S-N transect through the Eastern Karavanke Mountains.

**Derivation of name:** After facies characters.

**Synonyms:** Gebankte Kalke (KUPSCH et al., 1971); schillreiche Kalke (LOESCHKE & ROLSER, 1971: p. 153); Kalk (MOSHAMMER, 1989: Fig. 3).

**Lithology:** Grey bioclastic flaser limestone.

**Fossils:** Brachiopods, bryozoans, crinoids, conodonts, ostracods, trilobites.

**Origin, facies:** Marine limestone, neritic unit.

**Chronostratigraphic age:** Upper Ordovician (Katian).

**Biostratigraphy:** *ordovicicus* conodont zone (MOSHAMMER, 1989: p. 625).

**Thickness:** Approx. 8 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** -

**Overlying unit(s):** "Untere Schichten" (unconformable contact?).

**Lateral unit(s):** Equivalent units are seen within the Ordovician limestones of the Carnic Alps (MOSHAMMER, 1989).

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** Following KUPSCH et al. (1971) the south-alpine Paleozoic units of the Eastern Karavanke Mountains (Text-Fig. 4) are separated by the Triassic of the Koschuta (Trögen Klamm). The area to the south is called the Paleozoic of Seeberg (Seeberg Aufbruch sensu SIEWERT, 1984; informal) and the area north if it is known as Paleozoic of Eisenkappel (Trögen Group sensu MOSHAMMER & FLÜGEL, 1987; formalized). In general, the Seeberg Aufbruch ("Window") can be distinguished from the Trögen Group according to differences within the depositional environment that developed regionally (LOESCHKE & ROLSER, 1971; SIEWERT, 1984: p. 41–45; MOSHAMMER, 1990: Fig. 2).

**Complementary references:** LOESCHKE (1974), JAEGER et al. (1975), SCHÖNLAUB (1979), MOSHAMMER (1987), SCHÖNLAUB & HISTON (1999, 2000), HUBMANN et al. (2003, 2006).

### „Untere Schichten“ / “Untere Schichten”

THOMAS J. SUTTNER

**Validity:** Invalid; "Untere Schichten" first mentioned by GAERTNER (1931); additional work on this unit has been done by KUPSCH et al. (1971) and SCHÖNLAUB (1979).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Feistritzgraben (SCHÖNLAUB, 1979).

**Derivation of name:** In the strict sense the name "Untere Schichten" represents a lithostratigraphic term that was introduced by GAERTNER (1931: p. 133).

**Synonyms:** Tonschiefer-Lydit-Sedimentation (KUPSCH et al., 1971).

**Lithology:** Blackish shale and sandstones.

**Fossils:** Brachiopods, graptolites.

**Origin, facies:** Marine limestone, neritic unit.

**Chronostratigraphic age:** Upper Ordovician (Hirnantian).

**Biostratigraphy:** *persculptus* graptolite zone (SCHÖNLAUB, 1979: Fig. 19, p. 45).

**Thickness:** Approx. 20 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Coquina Limestones (unconformable contact?).

**Overlying unit(s):** Nodular Limestone (unconformable contact).

**Lateral unit(s):** Equivalent units are exposed within the Carnic Alps (JAEGER et al., 1975).

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** LOESCHKE (1974), SCHÖNLAUB & HISTON (1999, 2000).

### Knollenkalk / Nodular Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; mentioned by ROLSER (1968) and KUPSCH et al. (1971); biostratigraphy of an equivalent, but more distally deposited unit by MOSHAMMER (1989).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Section near Gehöft Illitsch south of Finkenstein (SCHÖNLAUB, 1979); Trögen Klamm section-group A (N 46°28'04" / E 14°30'28"), B (N 46°28'00" / E 14°30'24"), E (N 46°28'00" / E 14°30'30") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After facies characters.

**Synonyms:** grobspätige Crinoidenkalkfazies (SCHÖNLAUB, 1975); schwarze Kieselschiefer (MOSHAMMER, 1989).

**Lithology:** Bedded crinoidal limestone, dark siliceous shale.

**Fossils:** Brachiopods, chitinozoans, conodonts, crinoids, trilobites.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Llandovery.

**Biostratigraphy:** *stauognathoides* and *celloni* conodont zones (MOSHAMMER, 1989: p. 625).

**Thickness:** Approx. 15 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** "Untere Schichten" (unconformable contact).

**Overlying unit(s):** Cardiola Formation (unconformable contact).

**Lateral unit(s):** -

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** LOESCHKE & ROLSER (1971), LOESCHKE (1974), SCHÖNLAUB (1979), TESSENHORN (1983), MOSHAMMER (1987), SCHÖNLAUB & HISTON (1999, 2000).

**Cardiola-Formation / Cardiola Formation**  
(description see Carnic Alps)

**Alticola-Kalk / Alticola Limestone**  
(description see Carnic Alps)

**Platten-Kalk / Platy Limestone**  
THOMAS J. SUTTNER

**Validity:** Invalid; known since TELLER (1886a); lithology and biostratigraphy by SCHULZE (1968), TESSENHORN (1974b) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Christophorus-Fels (SCHÖNENBERG, 1965: Fig. 2, p. 32), N 46°26'14" / E 14°33'28"; Kleiner Pasterk-Pasterkhube (N 46°26'12" / E 14°32'50"), Paulitsch Wand (N 46°25'05" / E 14°34'48"), Plasnik (N 46°26'02" / E 14°35'02"), Sadonig Höhe (N 46°26'09" / E 14°35'26"), south of Storschitz (N 46°25'29" / E 14°31'41") published by TESSENHORN (1974b); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), E (N 46°28'00" / E 14°30'30"), F2 (N 46°28'01" / E 14°30'18") and the detailed section of Malowerschnig (N 46°28'01" / E 14°30'09") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After facies characters.

**Synonyms:** Dunkel-rauchgraue dolomitische Plattenkalke (TELLER, 1886a); dunkle Plattenkalke des obersten Silur (ey) (SCHÖNENBERG, 1965: Fig. 2, p. 31); ey-Kalke (SCHULZE, 1968); gebankte, hellgrau-schwarze fossilarme Kalke (MOSHAMMER, 1989).

**Lithology:** Well bedded micritic limestones, upper part of the unit consists of tentaculite-bearing flaser limestone.

**Fossils:** Brachiopods, conodonts, crinoids, orthocerids, ostracods, tentaculites, trilobites.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Pridoli-Lochkovian.

**Biostratigraphy:** *eosteinhornensis*, *woschmidti*, *delta* and *pesavis* conodont zones (SCHULZE, 1968; TESSENHORN, 1974b; MOSHAMMER, 1989).

**Thickness:** Approx. 40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Alticola Limestone (conformable contact).

**Overlying unit(s):** Bronteus Limestone (conformable contact).

**Lateral unit(s):** Orthoceratid Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** SCHULZE (1964), SCHÖNENBERG (1967), KUPSCH et al. (1971), TESSENHORN (1974a), SCHÖNLAUB (1979), MOSHAMMER (1987), RANTITSCH (1990, 1992b), RAMOVŠ (1999), SCHÖNLAUB & HISTON (1999, 2000).

**Orthoceras-Kalk / Orthoceratid Limestone**  
THOMAS J. SUTTNER

**Validity:** Invalid; first mentioned by TELLER (1886b); later described by ROLSER (1968); lithological and biostratigraphical analysis by MOSHAMMER (1989).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Trögen Klamm section-group F1 (N 46°28'02" / E 14°30'12") and the detailed section of Malowerschnig (N 46°28'01" / E 14°30'09") published by MOSHAMMER (1989); Jezersko (Ober-Seeland) (RAMOVŠ, 1971).

**Derivation of name:** After facies characters.

**Synonyms:** Orthocerenkalke (ROLSER, 1968).

**Lithology:** Light grey to reddish bedded limestone with nodular bedding planes (ROLSER, 1968: p. 54).

**Fossils:** Brachiopods, conodonts, crinoids, orthocerids, ostracods.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Wenlock to Pridoli.

**Biostratigraphy:** *bohemica* conodont zone (equivalent of *crassa* Zone in MOSHAMMER 1989: Fig. 10, p. 625).

**Thickness:** 30–40 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Cardiola Formation (conformable contact).

**Overlying unit(s):** Bronteus Limestone (conformable contact).

**Lateral unit(s):** Alticola Limestone, Platy Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** TELLER (1887), KUPSCH et al. (1971), SCHÖNLAUB (1979), MOSHAMMER (1987, 1990), SCHÖNLAUB & HISTON (1999, 2000).

**Bronteus-Kalk / Bronteus Limestone**  
THOMAS J. SUTTNER

**Validity:** Invalid; mapped by LIPOLD (1856b) and TELLER (1886a); lithological logs and biostratigraphy by SCHULZE (1968), TESSENHORN (1974a) and MOSHAMMER (1989, 1990); name already mentioned by STACHE (1884) when comparing units of the Karavanke Mountains with the Graz Paleozoic; the term was first applied for this unit (in the Karavanke Mountains) by SCHÖNLAUB (1979).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Christophorus-Fels (SCHÖNENBERG, 1965: Fig. 2, p. 32), N 46°26'15" / E 14°33'30"; Kleiner Pasterk-Pasterkhube (N 46°26'12" / E 14°32'49"), Plasnik (N 46°26'03" / E 14°35'00"), Sadonig Höhe (N 46°26'10" / E 14°35'42"), Storschitz (N 46°25'44" / E 14°31'37") pub-

lished by SCHULZE (1968); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), D (N 46°28'03" / E 14°30'33"), F1 (N 46°28'02" / E 14°30'12") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After the generic name of the trilobite *Bronteus transversus* (BARRANDE) (Suess, 1858).

**Synonyms:** Gailthaler Kalk (LIPOLD, 1856b: p. 350); rötlich-graue bis fleischrote Oolith-Marmore (TELLER, 1886a); fleischrote Kalke des unt. Unterdevon (F 2) (SCHÖNENBERG, 1965: Fig. 2, p. 31); rotgeflammt Kalk (SCHULZE, 1968); fleischroter Kalk (SCHULZE, 1968); Rote Flaserkalke ("F2") (TESSENSOHN, 1974a); Bunter Bronteus-Kalk (SCHÖNLAUB, 1979); "dehiscens"-Kalk (MOSHAMMER, 1989).

**Lithology:** Red flaser limestone with interbedded crinoidal limestones.

**Fossils:** Bivalves, brachiopods, cephalopods, corals (rare), conodonts, crinoids, gastropods, ostracods, tentaculites, trilobites.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Pragian–Emsian.

**Biostratigraphy:** *kitabicus* and *gronbergi* conodont zones (SCHULZE, 1968; MOSHAMMER, 1989).

**Thickness:** Approx. 30 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Platy Limestone (conformable contact), Orthoceratid Limestone (conformable contact).

**Overlying unit(s):** Reef Limestone (conformable contact); Seeland Crinoidal Limestone (conformable contact); Seeberg Coral-Crinoidal Limestone (conformable contact); Limestone, Lydites (conformable contact).

**Lateral unit(s):** Seeberg Shale.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** TIETZE (1870), TELLER (1886b), PENECKE (1887), SCHULZE (1964), SCHÖNENBERG (1965, 1967), KUPSCH et al. (1971), TESSENSOHN (1974b), SCHÖNLAUB (1979), MOSHAMMER (1987), RANTITSCH (1990, 1992b), RAMOVŠ (1999), SCHÖNLAUB & HISTON (1999, 2000).

### Seeberg-Schiefer / Seeberg Shale

THOMAS J. SUTTNER

**Validity:** Invalid; lithological characters and biostratigraphic implications provided by LOESCHKE & ROLSER (1971); name first mentioned by TESSENSOHN (1974a).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** About 1 km southwest of Sadonig Höhe (LOESCHKE & ROLSER, 1971: p. 154), N 46°25'57" / E 14°35'10".

**Derivation of name:** After Seeberg Pass (TESSENSOHN, 1974a: p. 113).

**Synonyms:** Devonische Vulkanite in Vellach (LOESCHKE & ROLSER, 1971: p. 154).

**Lithology:** Greywacke, shale with interbeds of siliceous shale and volcanites, bedded limestone.

**Fossils:** Conodonts.

**Origin, facies:** Pelagic marine deposits dominated by shales, siliceous shales, tuffs and volcanites; note wrong color code in the ASC 2004.

**Chronostratigraphic age:** According to LOESCHKE & ROLSER (1971: Fig. 4, p. 154) Emsian–Famennian age is concluded based on conodonts that were obtained from limestone intercalations at the base of the sequence at the village of Vellach.

**Biostratigraphy:** -

**Thickness:** Few cm to 20 m (following LOESCHKE & ROLSER, 1971).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bronteus Limestone (conformable contact).

**Overlying unit(s):** Bronteus Limestone (conformable contact).

**Lateral unit(s):** Bronteus Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** ROLSER (1968), KUPSCH et al. (1971), SCHÖNLAUB (1979), TESSENSOHN (1983), SCHÖNLAUB & HISTON (1999, 2000).

### Riffkalk / Reef Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; first observed by TIETZE (1873); general lithological description by KUPSCH et al. (1971); biostratigraphy by SCHULZE (1968); facies and biostratigraphy of an equivalent, but more distally deposited unit within the Trögen Group by MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Christophorus-Fels (SCHÖNENBERG, 1965: Fig. 2, p. 32), N 46°26'08" / E 14°33'30"; Grosser Pasterk (N 46°26'25" / E 14°32'29"), Rapold (N 46°26'16" / E 14°33'13") published by SCHULZE (1968); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After facies characters.

**Synonyms:** Durch Corallen ausgezeichnete obersilurische Kalke (TIETZE, 1873: p. 183–184); Rapoldriff (SCHULZE, 1968); Devonkalke ungegl. (SCHÖNENBERG, 1965: Fig. 2, p. 31); Riff- und Riffschuttkalk (KUPSCH et al., 1971); massive Riffschuttbrekzie (MOSHAMMER, 1990: Fig. 2).

**Lithology:** Bioclastic limestone.

**Fossils:** Brachiopods, calcareous algae, conodonts, corals, ostracods, stromatoporoids.

**Origin, facies:** Marine limestone, neritic unit.

**Chronostratigraphic age:** Emsian–Famennian.

**Biostratigraphy:** *australis*, *ensensis*, *triangularis* and *crepida* conodont zones (SCHULZE, 1968; MOSHAMMER, 1989: Fig. 10).

**Thickness:** Approx. 250 m (according to KUPSCH et al., 1971).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bronteus Limestone (conformable contact).

**Overlying unit(s):** Limestones (unconformable contact).

**Lateral unit(s):** Seeland Crinoidal Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** PENECKE (1887), TESSENSOHN (1974a), SCHÖNLAUB (1979), MOSHAMMER (1987), RANTITSCH (1990, 1992b), FENNINGER & HUBMANN (1994), SCHÖNLAUB & HISTON (1999, 2000), HUBMANN et al. (2003).

### Seeland Crinoidenkalk / Seeland Crinoidal Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; first recognized by LIPOLD (1856a); named by FRECH (1894a); lithological and biostratigraphic investigations by SCHULZE (1968), TESSENSOHN (1974b) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Grosser Pasterk (N 46°26'24" / E 14°32'31"), Kleiner Pasterk-Pasterkhube (N 46°26'12" / E 14°32'45"), Paulitsch Wand (N 46°25'10" / E 14°34'40"), Plasnik (N 46°26'05" / E 14°34'54"), Sadonig Höhe (N 46°26'12" / E 14°35'42"), Storschitz (N 46°25'46" / E 14°31'33") published by TESSENSOHN (1974b); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After lithological characters of the unit at the Seeland section (FRECH, 1894a).

**Synonyms:** Gailthaler Schichten [partim] (LIPOLD, 1856a); Seeländer Storžič (TELLER, 1886b); Seeländer Krinoidenbrekzie (FRECH, 1894a); graublaue Krinoidenbrekzienkalke und graublaue splitterige Kalke (HERITSCH, 1927d); Krinoiden- und Korallenkalk (SCHULZE, 1968); grauer Riffkalk (mit Krinoiden und Korallen) (SCHULZE, 1968); Crinoidenkalke (TESSENSOHN, 1974b); Seeländer Crinoidenbreccie (SCHÖNLAUB, 1979); Slump aus Flaserkalk und sparitischen Schuttkalk (MOSHAMMER, 1990: Fig. 2).

**Lithology:** Bioclastic limestone.

**Fossils:** Conodonts, crinoids, corals, stromatoporoids.

**Origin, facies:** Marine limestone, neritic unit, fore reef facies (SIEWERT, 1984).

**Chronostratigraphic age:** Emsian–Frasnian.

**Biostratigraphy:** *serotinus* and *patulus* conodont zones (MOSHAMMER, 1989).

**Thickness:** Approx. 200 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bronteus Limestone (conformable contact).

**Overlying unit(s):** Limestones (unconformable contact).

**Lateral unit(s):** Reef Limestone; Seeberg Coral-Crinoidal Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** PENECKE (1887), TESSENSOHN (1974a), SCHÖNLAUB (1979), MOSHAMMER (1987), RANTITSCH (1990, 1992b), SCHÖNLAUB & HISTON (1999, 2000).

### Seeberger Korallen-Crinoidenkalk / Seeberg Coral-Crinoidal Limestone

THOMAS J. SUTTNER

**Validity:** Invalid; first recognized by LIPOLD (1856b); named by STACHE (1884); lithological and biostratigraphic investigations by SCHULZE (1968), TESSENSOHN (1974b) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Grosser Pasterk (N 46°26'19" / E 14°32'29"), Jeritsch-Felsen (N 46°24'52" / E 14°32'37"), south of Storschitz (N 46°25'29" / E 14°31'24") published by TESSENSOHN (1974b); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After coral and crinoid bearing limestones in the surroundings of Seeberg Pass (STACHE, 1884).

**Synonyms:** Gailthaler Kalk (LIPOLD, 1856b: p. 350); Seeberger Korallen- und Crinoidenkalk (STACHE, 1884: Tab. at end of publication); Crinoiden- und Korallenkalke (TELLER, 1886a); Korallenkalke und Crinoidenkalkbreccien (TELLER, 1886b); Seeberger Riffkalke (TELLER, 1886b); Riffkalke des Seeberges (TELLER, 1886c); grauer spätiger Kalk des Mitteldevon (SCHULZE, 1968); Riff- und Riffschuttkalk (KUPSCH et al., 1971); Korallenkalke (TESSENSOHN, 1974b); "Riff-Rudstone" (MOSHAMMER, 1990: p. 574).

**Lithology:** Coral limestone with crinoidal limestone interbedded.

**Fossils:** Brachiopods, conodonts, corals, crinoids, ostracods, stromatoporoids.

**Origin, facies:** Marine limestone, neritic unit, reef core facies (compare SIEWERT, 1984).

**Chronostratigraphic age:** Emsian–Famennian.

**Biostratigraphy:** *australis* and *ensensis* conodont zones (MOSHAMMER, 1989).

**Thickness:** Approx. 250 m (following KUPSCH et al., 1971).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bronteus Limestone (conformable contact).

**Overlying unit(s):** Limestones (unconformable contact).

**Lateral unit(s):** Seeland Crinoidal Limestone; Limestones, Lydites; Lydites, Limestone Breccia; Shale, Limestones.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** PENECKE (1887), SCHÖNLAUB (1971b, 1979), TESSENSOHN (1974a), MOSHAMMER (1987), RANTITSCH (1990, 1992b), RAMOVŠ (1999), SCHÖNLAUB & HISTON (1999, 2000).

### Kalke, Lydite / Limestones, Lydites

THOMAS J. SUTTNER

**Validity:** Invalid; described by KUPSCH et al. (1971); lithological characters and biostratigraphy by TESSENSOHN (1974a) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Stanwiese section in Vellach (TESSENSOHN, 1974a: p. 115); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After dominating lithologies.

**Synonyms:** Dunkelblaugraue, gebankte, verkieselte Schuttkalke (MOSHAMMER, 1990: Fig. 2); schwarzer Lydit (MOSHAMMER, 1990); "Radiolarien Chert" (MOSHAMMER, 1990: p. 575).

**Lithology:** Blackish limestone alternating with lydites and blackish shale.

**Fossils:** Conodonts, crinoids, radiolarians.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Emsian–Givetian.

**Biostratigraphy:** *varcus* conodont zone (MOSHAMMER, 1989).

**Thickness:** Approx. 30 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Bronteus Limestone (conformable contact).

**Overlying unit(s):** Lydites, Limestone Breccia (conformable contact).

**Lateral unit(s):** Seeberg Coral-Crinoidal Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** SCHÖNLAUB (1971b, 1979), MOSHAMMER (1987), SCHÖNLAUB & HISTON (1999, 2000).

### Lydite, Kalkbreckzie / Lydites, Limestone Breccia

THOMAS J. SUTTNER

**Validity:** Invalid; first recognized by LIPOLD (1856b); later described by KUPSCH et al. (1971); lithologically defined and biostratigraphically dated by TESSENSOHN (1974a) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Hainschgraben near Zell Pfarre (Eisenkappel area); Stanwiese section in Vellach (TESSENSOHN, 1974a: p. 115); Trögen Klamm section-group B (N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After dominating lithologies.

**Synonyms:** Gailthaler Schichten (Kalk und Schiefer) (LIPOLD, 1856b: p. 349); schwarzer Lydit (MOSHAMMER, 1990: Fig. 2); "Radiolarien Chert" (MOSHAMMER, 1990: p. 575).

**Lithology:** Limestone breccia (with pebble sized components of reef rubble), lydite alternating with limestone beds.

**Fossils:** Conodonts, corals, crinoids, radiolarians.

**Origin, facies:** Marine pelagic deposits; note wrong color code in the ASC 2004.

**Chronostratigraphic age:** Givetian–Frasnian.

**Biostratigraphy:** *varcus* conodont zone (MOSHAMMER, 1989).

**Thickness:** Approx. 6 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Limestones, lydites (conformable contact).

**Overlying unit(s):** Shale, limestones (conformable contact).

**Lateral unit(s):** Seeberg Coral-Crinoidal Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** SCHÖNENBERG (1965, 1967), SCHÖNLAUB (1979), MOSHAMMER (1987), SCHÖNLAUB & HISTON (1999, 2000).

### Tonschiefer, Kalke / Shale, Limestones

THOMAS J. SUTTNER

**Validity:** Invalid; first recognized by LIPOLD (1856b); later described by KUPSCH et al. (1971); lithologically defined and biostratigraphically dated by TESSENSOHN (1974a) and MOSHAMMER (1989, 1990).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** Stanwiese section in Vellach (TESSENSOHN, 1974a: p. 115); Trögen Klamm section-group B

(N 46°28'00" / E 14°30'24"), C (N 46°27'59" / E 14°35'03"), E (N 46°28'00" / E 14°30'30"), F1 (N 46°28'02" / E 14°30'12"), F2 (N 46°28'01" / E 14°30'18") published by MOSHAMMER (1989, 1990).

**Derivation of name:** After dominating lithologies.

**Synonyms:** Gailthaler Schichten (Kalk und Schiefer) (LIPOLD, 1856b: p. 349); rötlicher, gebankter bis geflaseter Kalk (do II) (MOSHAMMER, 1989: Fig. 3); "Mudstone mit Cephalopoden" (MOSHAMMER, 1990: p. 575).

**Lithology:** Shale alternating with thin limestone layers.

**Fossils:** Cephalopods.

**Origin, facies:** Marine pelagic deposits; note wrong color code in the ASC 2004.

**Chronostratigraphic age:** Frasnian–Famennian.

**Biostratigraphy:** *marginifera* conodont zone (MOSHAMMER, 1989: p. 627).

**Thickness:** Approx. 2 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Lydites, limestone breccia (conformable contact).

**Overlying unit(s):** Limestones (unconformable contact).

**Lateral unit(s):** Seeberg Coral-Crinoidal Limestone.

**Geographic distribution:** Karavanke Mountains (Eisenkappel and Seeberg area).

**Remarks:** -

**Complementary references:** SCHÖNENBERG (1965, 1967), SCHÖNLAUB (1971a, 1979), MOSHAMMER (1987), SCHÖNLAUB & HISTON (1999, 2000).

### Kalke / Limestones

THOMAS J. SUTTNER

**Validity:** Invalid; first recognized by LIPOLD (1856b) and TELLER (1898); later described by KOLLMANN (1938) and KUPSCH et al. (1971); biostratigraphy by SCHULZE (1968).

**Type area:** ÖK50-UTM, map sheet 4114 Bad Eisenkappel (ÖK50-BMN, map sheets 212 Vellach, 213 Bad Eisenkappel).

**Type section:** -

**Reference section(s):** South-east of Storschitz, between Seebergpaß and Jeritsch-Felsen (N 46°25'09" / E 14°32'10"; N 46°25'11" / E 14°31'49"), south-west of the Pasterkfelden (N 46°25'42" / E 14°32'48") published by SCHULZE (1968).

**Derivation of name:** After lithology.

**Synonyms:** Gailthaler Kalk (LIPOLD, 1856b: p. 350); Devon in Bänderkalkfazies (KOLLMANN, 1938); Bänderkalkschuppen (KUPSCH et al., 1971: Fig. 2, p. 95); Bänderkalke (KUPSCH et al., 1971: Fig. 3, p. 95); graue Bänderkalke bzw. Graue spätige Kalke des Unter-Karbon (SCHULZE, 1968); banded limestone (SCHÖNLAUB, 1980b).

**Lithology:** Grey, laminated limestone (reddish brown weathering), grey sparry limestone.

**Fossils:** Brachiopods, cephalopods, conodonts, crinoids.

**Origin, facies:** Marine limestone, pelagic unit.

**Chronostratigraphic age:** Tournaisian.

**Biostratigraphy:** *anchoralis* conodont zone (SCHULZE, 1968: p. 176); middle *Gattendorfia* ammonoid zone to middle *Pericyclus* ammonoid zone (SCHULZE, 1968: p. 176).

**Thickness:** Approx. 300 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Reef Limestone; Seeland Crinoidal Limestone; Seeberg Coral-Crinoidal Limestone; Shale, Limestones (all units mentioned: unconformable contact).

**Overlying unit(s):** Hochwipfel Formation (unconformable contact).

**Lateral unit(s):** -

**Geographic distribution:** Karavanke Mountains (Seeberg area).

**Remarks:** -

**Complementary references:** HERITSCH (1927d), SCHÖNLAUB (1979), KREUTZER et al. (1997), SCHÖNLAUB & HISTON (1999, 2000).

### Hochwipfel-Formation / Hochwipfel Formation (description see Carnic Alps)

## Post-Variscan Sequence

### Auernig-Gruppe / Auernig Group (see description in Carnic Alps)

### Rattendorf-Formation / Rattendorf Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid.

**Type area:** ÖK50-UTM, map sheet 3116 Sonnenalpe Naßfeld (ÖK50-BMN, map sheet 198 Weißbriach), Carnic Alps, Carinthia.

**Type section:** Not defined.

**Reference section(s):** Section on western cliff of Mountain Schulterkofel following the crest south of Rattendorfer Alm to Zottachkopf (HERITSCH et al., 1934: p. 176).

**Remarks:** According to HERITSCH et al. (1934: p. 163) the post-Variscan sequence of the Carnic Alps is subdivided into the "Auernig-Schichten" and the "Rattendorfer Schichten" ranging from the upper Carboniferous to the Lower Permian. The latter were subdivided into the Lower Schwagerina Lst., the Grenzlandbänke and the Upper Schwagerina Lst.

**Derivation of name:** After the village of Rattendorf west of Hermagor to which the pastures around Rattendorfer Alm belongs.

**Synonyms:** Rattendorfer Schichten.

**Lithology:** This lithostratigraphic unit is generally used to designate a Lower Permian sequence of limestones and clastics which cannot be further assigned to one of the Lower Permian formations, e.g., the Schulterkofel, Grenzland or Zweikofel Formation.



**Fossils:** Fusulinids, smaller foraminifers, phylloid algae and dasycladacean algae (*Anthracoporella*), crinoids, corals, brachiopods, bivalves.

**Origin, facies:** Shallow marine deposits in a moderately energetic environment.

**Chronostratigraphic age:** Asselian to lower Artinskian.

**Biostratigraphy:** -

**Thickness:** According to HERITSCH et al. (1934) the total thickness in the reference section is 285 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Auernig Group.

**Overlying unit(s):** Trogkofel Limestone.

**Lateral unit(s):** -

**Geographic distribution:** Carnic Alps, mainly west of Naßfeld crossing the Austrian/Italian border and in particular in the Karavanke Mountains.

**Remarks:** -

**Complementary references:** SCHÖNLAUB & FORKE (2007).

#### **Klastische Trogkofel-Formation / Clastic Trogkofel Formation**

HANS P. SCHÖNLAUB

**Validity:** Invalid; first mention ("clastic facies development of Trogkofel beds") by RAMOVŠ (1963: p. 382).

**Type area:** Karavanke Mountains, northern Slovenia.

**Type section:** A type section for the "Clastic Trogkofel beds" has never been denominated.

**Reference section(s):** -

Remarks: The following sections form the Karavanke Mts. have been described as "Clastic Trogkofel beds" in the literature:

- southern slope of Košuta range along the river Košutnik (KOCHANSKY-DEVIDÉ et al., 1973): this section belongs to the Schulterkofel Formation (late Gzhelian) (FORKE, 2002).
- clastic-carbonate deposits above the Dovžanova soteska limestone (BUSER, 1974): this section belongs to the recently established Born Formation (middle-late Asselian) (FORKE, 2002).

The term "Clastic Trogkofel beds" should no longer be maintained, as it represents a mixture of clastic-carbonate sequences ranging from late Gzhelian to Roadian (Wordian?). Sections from the Slovenian part of the Karavanke Mountains, which have been so far reinvestigated, reveal that these sequences belong to various lithologic units (see below), which are older than the Trogkofel Limestone itself. The occurrence of Kungurian (uppermost

Lower Permian) conodonts (RAMOVŠ, 1982) in small limestone lenses of a clastic sequence in the Eastern Karavanke Mts. near Solčava remains enigmatic. The finding could never be confirmed in subsequent investigations (pers. comm. BUSER).

"Clastic Trogkofel beds" mentioned in the explanatory notes of the geological map of the Karavanke Mts. (BAUER et al., 1983) need to be re-evaluated, before they can be implemented in a general lithostratigraphic framework.

Sediments from southern Slovenia (Ortnek, Kočevje) should be treated separately, as they display similarities to the facies development in NW Croatia (Gorski Kotar). The age of these deposits is still under discussion. However, the association of Visean deep-water conodonts, Lower Permian deep-water radiolarians, upper Carboniferous–Lower Permian deep-water fusulinids in various clasts and Roadian ammonoids reveal a complex history of these deposits, which is yet not well understood.

**Derivation of name:** -

**Synonyms:** Instead of Klastische Trogkofelschichten also the term "Kosna-Folge" (Košna beds) has been used (E. FLÜGEL, 1975; BUGGISCH et al., 1976) in the lithostratigraphic schemes of the Karavanke Mts.

**Lithology:** Clastic carbonates.

**Fossils:** Conodonts, fusulinids, ammonoids.

**Origin, facies:** Various reworking horizons (see remarks above).

**Chronostratigraphic age:** Late Gzhelian–Roadian (Wordian?) (see above).

**Biostratigraphy:** -

**Thickness:** ? (see remarks above).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** - (see remarks above).

**Overlying unit(s):** - (see remarks above).

**Lateral unit(s):** -

**Geographic distribution:** Southern slope of Košuta range and Dovžanova soteska.

**Remarks:** -

**Complementary references:** -

#### **Gröden-Formation / Gröden Formation** (see description in Carnic Alps)

#### **Bellerophon-Formation / Bellerophon Formation** (see description in Carnic Alps)

### **Karbon von Nötsch / Carboniferous of Nötsch**

The famous fossiliferous outcrops of the Carboniferous of Nötsch are located in the Gail Valley between Windische Höhe and Mount Dobratsch. The name-bearing village of Nötsch, however, is situated in the Gailtal Crystalline Complex following to the south of the Carboniferous deposits.

Since the beginning of the 19<sup>th</sup> century the Carboniferous of Nötsch has been famous for its abundance of fos-

sils and thus has attracted many geologists and paleontologists. The east-west directed exposures extend as a narrow fault-bounded wedge over a distance of 8 km, the maximum width of which is 2 km in the east. Further to the west the Carboniferous rocks are squeezed out between the above-mentioned rocks and are also covered by Quaternary deposits, respectively.

The tectonic significance of these Carboniferous rocks has raised many controversial statements in the past. In fact, the true relationship between the Carboniferous sediments and the surrounding units of the Gailtal Crystalline Complex and the Permo-Triassic sequence of the Drauzug has long been a matter of debate and has not yet been solved satisfactorily.

### Erlachgraben-Formation / Erlachgraben Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; first denomination and formalization by SCHÖNLAUB (1985d: p. 677–679).

**Type area:** ÖK50-UTM, map sheet 3111 Spittal an der Drau (ÖK50-BMN, map sheets 199 Hermagor, 200 Arnoldstein), Carinthia.

**Type section:** Southern slope of Erlachgraben (N 46°37'47" / E 13°35'36").

**Reference section(s):** Southwest dipping section between the Erlachgraben and its northern tributaries and the mountain Badstuben.

**Derivation of name:** After the valley of Erlachgraben west of the village of Bleiberg-Kreuth.

**Synonyms:** Erlachgraben-Folge of KODSI & FLÜGEL (1968, 1970); northern part of Nötschgraben-Folge below the Badstub Formation; Pölland Gruppe (KODSI & FLÜGEL, 1970).

**Lithology:** Dark grey arenaceous shales with interbedded quartz-rich conglomerates in the lower part grading into sandstones and micaceous siltstones above.

**Fossils:** Brachiopods, nautiloids, trilobites, bivalves (see SCHÖNLAUB, 1985d; SCHRAUT, 1999), crinoids, corals, gastropods, goniatites, smaller foraminifers, calcareous algae, trace fossils and plants (KABON, 1997; VAN AMEROM & KABON, 1999, 2000, 2003).

**Origin, facies:** Sediments of an upper continental slope with redeposited fossils from shallow marine areas (KRAI-NER, 1992).

**Chronostratigraphic age:** Uppermost Visean or lower Serpukhovian ("Namurian").

**Biostratigraphy:** Flora with *Archaeopteridium tschermakii* indicates Arnsbergium (middle Namurian A).

**Thickness:** > 500 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** No basement known.

**Overlying unit(s):** Badstub Formation.

**Lateral unit(s):** -

**Geographic distribution:** Gail Valley between Windische Höhe in the west and Mount Dobratsch (Villacher Alpe) in the east. It culminates in the peak Badstube (1,369 m) and is crossed by the Nötsch River (see map by SCHÖNLAUB, 1985d).

**Remarks:** -

**Complementary references:** -

### Badstub-Formation / Badstub Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; first denomination and formalization by SCHÖNLAUB (1985d: p. 679–682).

**Type area:** ÖK50-UTM, map sheet 3111 Spittal an der Drau (ÖK50-BMN, map sheets 199 Hermagor, 200 Arnoldstein), Carinthia.

**Type section:** Nötsch Creek (N 46°37'05" / E 13°36'49").

**Reference section(s):** Middle part of Nötsch River (Nötschbachgraben) where the bipartite Badstub Formation is exposed on the eastern and western hillsides. The best outcrop is quarried in the huge Jakomini Quarry.

**Derivation of name:** Named after the mountain Badstube (1,369 m), the highest peak in the region occupied by the Carboniferous sequence of Nötsch.

**Synonyms:** Badstub-Brekzie (SCHÖNLAUB, 1985d), Badstub-Serie (FELSER, 1935), Diabas I, II (SCHÖNLAUB, 1973).

**Lithology:** Greenish matrix-supported breccia consisting of angular to subrounded cm to dm-sized clasts of amphibolites, gneisses, granites, micaschists, quartzites, marbles and limestones.

**Fossils:** Brachiopods (*Gigantoproductus*), conodonts, foraminifers.

**Origin, facies:** Marine debris flows and turbidites on an upper slope.

**Chronostratigraphic age:** Serpukhovian.

**Biostratigraphy:** Based on conodonts (*Lochriea nodosa*), foraminifers (*Howchinia bradyana* (HOWCHIN)) and plants (*Lepidodendron* sp.) in exotic limestone clasts (FLÜGEL & SCHÖNLAUB, 1990).

**Thickness:** 350–400 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Erlachgraben Formation.

**Overlying unit(s):** Nötsch Formation.

**Lateral unit(s):** -

**Geographic distribution:** Northern side of Gail Valley between Windische Höhe in the west and Mount Dobratsch (Villacher Alpe) in the east (see map by SCHÖNLAUB, 1985d).

**Remarks:** -

**Complementary references:** -

### Nötsch-Formation / Nötsch Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; first denomination and formalized by SCHÖNLAUB (1985d: p. 682–684).

**Type area:** ÖK50-UTM, map sheet 3111 Spittal an der Drau (ÖK50-BMN, map sheets 199 Hermagor, 200 Arnoldstein), Carinthia.

**Type section:** Composite section in the middle part of Nötsch River (Nötschbachgraben) (N 46°36'50" / E 13°36'41").

**Reference section(s):** The area around Fischerhube (Oberhöher) and the area west of mountain Badstube between Windische Höhe, Pölland and Matschiedl.

**Derivation of name:** Named after the village of Nötsch in the Gail Valley.

**Synonyms:** Upper part of the Nötschgraben-Gruppe and Pölland-Gruppe in FLÜGEL & KODSI (1968) and KODSI & FLÜGEL (1970).

**Lithology:** Clastic sequence of greyish shales, mudstones, siltstones, sandstones and medium to coarse grained conglomerates.

**Fossils:** Trilobites, rugose corals, brachiopods, goniatites, nautiloids, gastropods, crinoids, echinoids, ophiocistoids, bryozoans, phyllocarids, arachnids (spiders), monoplacophores, serpulids, plants (see SCHRAUT, 1999).

**Origin, facies:** Shallow marin, below storm wave base.

**Chronostratigraphic age:** Serpukhovian.

**Biostratigraphy:** Based on corals and plants (*Lepidophyta*, *Calamites*).

**Thickness:** 400–600 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Badstub Formation.

**Overlying unit(s):** Gröden Formation (?). The contact between the two units is, however, not exposed.

**Lateral unit(s):** -

**Geographic distribution:** Northern side of Gail Valley between Windische Höhe in the west and Mount Dobratsch (Villacher Alpe) in the east (see map by SCHÖNLAUB, 1985d).

**Remarks:** -

**Complementary references:** -

## Drauzug / Drau Range

The base of the Mesozoic Drau Range is composed of late to post-Variscan sediments of early to late Permian ages. These sediments reach up some 500 m in thickness and overlie unconformably different types of metamorphic rocks ("Gailtalkristallin"). The sedimentary sequence is characterized by molasse-type sediments deposited in intermontane basins which were formed by block and wrench faulting during the late orogenic stage of the Variscan cycle. The Permian sedimentation took place under increasingly semiarid to arid climatic conditions; the sudden alteration in sedimentation (Alpine Buntsandstein), obviously caused by a climatic change presumably represents the Permian/Triassic boundary (KRAINER, 1993c).

### Laas-Formation / Laas Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; first denomination and formalized by NIEDERMAYR & SCHERIAU-NIEDERMAYR (1982: p. 35–40).

**Type area:** ÖK50-UTM, map sheet 3110 Kötschach-Mauthen (ÖK50-BMN, map sheet 197 Kötschach), Carinthia, between Gailberg Pass and Maiengraben near the village of St. Daniel.

**Type section:** N 45°41'39" / E 13°00'57". Northeast of the small village of Lanz (1,038 m) NNE of Kötschach at an altitude of 1,300 m along the forest road from Lanz to Stelzling Hütte (NIEDERMAYR & SCHERIAU-NIEDERMAYR, 1982: p. 37; KRAINER, 1990b: p. 64)

**Reference section(s):** Tiebelgraben, Riedgraben between the villages Paternion and Stockenboi (KRAINER, 1990b) on ÖK50-BMN, map sheets 199 Hermagor, 200 Arnoldstein.

**Derivation of name:** Named after the village of Laas northwest of Kötschach-Mauthen.

**Synonyms:** Postvariszische Transgressionsserie, Liegende Serie, Serie von Laas, Laaser Schichten, Kontinentaldetritisches Perm, Freudenberg Schichten (RIEHL-HERWIRSCH, 1965, 1972; NIEDERMAYR, 1975; NIEDERMAYR & SCHERIAU-NIEDERMAYR, 1982; KRAINER, 1985, 1990b, 1993b).

**Lithology:** Conglomerates, breccias, red and grey sandstones and siltstones.

**Fossils:** Plants, ostracods, *Spirorbis*, fish scales, tetrapod imprints (*Ichniotherium cottae*), root and soil horizons, plants.

**Origin, facies:** Clastic proximal to distal alluvial fan deposits intercalated with highly bioturbated playa-sediments and up to 80 m thick rhyolitic pyroclastics (ash flow tuffs, ignimbrites) in the upper part.

**Chronostratigraphic age:** Asselian (Lower Permian).

**Biostratigraphy:** *callipteris conferta* Zone.

**Thickness:** Up to 150 meters.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Gailtal Crystalline Complex.

**Overlying unit(s):** Coarse clastics of the Gröden Formation.

**Lateral unit(s):** -

**Geographic distribution:** Northern side of Gail Valley overlying the Gailtal Crystalline Complex in the surroundings north of Kötschach-Mauthen (see map by SCHÖNLAUB, 1985c) as well as on the northern side of the Gailtal Alps (Drauzug).

**Remarks:** -

**Complementary references:** -

### Gröden-Formation / Gröden Formation

(see also description in Carnic Alps)

HANS P. SCHÖNLAUB

**Validity:** See entry Gröden Formation in Carnic Alps.

**Type area:** See entry Gröden Formation in Carnic Alps.

**Type section:** See entry Gröden Formation in Carnic Alps.

**Reference section(s):** See entry Gröden Formation in Carnic Alps.

**Derivation of name:** See entry Gröden Formation in Carnic Alps.

**Synonyms:** See entry Gröden Formation in Carnic Alps.

**Lithology:** Coarse clastic sequence of conglomerates interbedded with red-colored sandstones interpreted as alluvial fan sequence of a braided river system in an semi-arid to arid climate. The red color is derived from finely dispersed hematite. Locally, in the middle part magnesite and dolomite bearing sand- and siltstones occur containing caliche crusts and playa sediments indicating a temporal evaporitic environment.

**Fossils:** In the lower part of the section fossil trees are intercalated in the basal portion identified as *Dadoxylon schrollianum*; also, spores have rarely been found.

**Origin, facies:** See entry Gröden Formation in Carnic Alps.

**Chronostratigraphic age:** Late Middle Permian due to reworked pebbles of quartzporphyritic composition presumably derived from the Bozen Quartzporphyry of the Dolomites.

**Biostratigraphy:** -

**Thickness:** Up to 350 meters.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Laas Formation and Gailtal Crystalline Complex, respectively.

**Overlying unit(s):** Alpinen Buntsandstein and Werfen Formation of the Triassic sequence.

**Lateral unit(s):** -

**Geographic distribution:** In the Gailtal Alps and Lienz Dolomites ("Drauzug").

**Remarks:** -

**Complementary references:** -

## Nördliche Kalkalpen / Northern Calcareous Alps

The thick Mesozoic sequences of the Northern Calcareous Alps are resting on predominantly clastic (Upper) Permian sediments. A primary (transgressive) contact to the underlying Greywacke Zone (e.g., Leobner Hut area near Eisenerz) is only rarely known due to overprint by Alpidic tectonic movements. In some cases a coherent connection between Permian "continental detritic" deposits and a Mesozoic cover is not traceable since they feature tectonic hangingwall boundaries (e.g., Silbersberg Nappes in NE Styria and Lower Austria, and Veitsch Nappe south of the Mürz Valley; NEUBAUER et al., 1994).

### Alpinen Verrucano / Alpine Verrucano

HANS P. SCHÖNLAUB

**Validity:** Invalid.

**Remarks:** The term "Alpinen Verrucano" was introduced by TOLLMANN (1962). TOLLMANN (1972: p. 83) defined this unit as coarse to fine detritic, weakly bedded continental Permian series deposited in an arid climate at the onset of the Alpine sedimentary cycle. Interbedded are acid volcanics and its debris. According to TOLLMANN (1972) and RIEHL-HERWIRSCH (1972) the "Alpinen Verrucano" should not be mixed with the "Verrucano Alpino" of ACCORDI (1956) which is restricted to the Lower Permian conglomerates overlying the Variscan sequence. Hence, RIEHL-HERWIRSCH (1972: p. 104) suggested to abandon this name and not to use it in further descriptions of tentatively similar rock sequences.

**Type area:** Not defined.

**Type section:** No type section defined.

**Reference section(s):** -

**Derivation of name:** After Castell Verruca in the Monte Pisani area (Tuscany/Italy).

**Synonyms:** -

**Lithology:** Mainly red, partly green, grey or brown coarse to fine grained conglomerates, sandstones and volcaniclastics.

**Fossils:** Rare and very badly preserved plant remains.

**Origin, facies:** Continental redbeds.

**Chronostratigraphic age:** Permian.

**Biostratigraphy:** -

**Thickness:** Up to 1,000 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Various units of the Variscan Alpine sequence.

**Overlying unit(s):** Triassic sequences of the Northern Calcareous Alps.

**Lateral unit(s):** -

**Geographic distribution:** The Alpine Verrucano occurs at the base of the Alpine orogenic cycle within the Austroalpine nappe system.

**Remarks:** -

**Complementary references:** -

### Präbichl-Formation / Präbichl Formation

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by SCHWINNER (1929) for the clastic post-Variscan cover overlying Devonian limestones between Leobner Hütte (1,582 m) and the mountain Polster (1,910 m) northeast of Präbichl Pass, Styria, at the base of the Northern Calcareous Alps.

**Type area:** ÖK50-UTM, map sheet 4215 Eisenerz (ÖK50-BMN, map sheet 101 Eisenerz), area between Polster Kar, Leobner Hütte and peak of Polster northeast of Präbichl Pass, Styria.

**Type section:** Northeastern directed section between "Knappensteig" west of Leobner Hütte and Hirschegg Sattel (1699 m) (N 47°32'00" / E 14°58'14").

**Reference section(s):** -

**Derivation of name:** After Präbichl Pass (1,226 m) in the Eisenerz Alps (Styria).

**Synonyms:** Prebichlschichten, Präbichlkonglomerat (SCHWINNER, 1929; CORNELIUS, 1936); Werfener Basisbrekzie (HIESSLEITNER, 1931, 1935); Basiskonglomerat der Werfener Schichten (HABERFELNER, 1935); Präbichlschichten (KRAINER & STINGL, 1986).

**Lithology:** Generally, the predominantly red clastic sequence starts with an up to 50 m thick limestone conglomerate containing pebbles from the underlying strata (limestones, siderite, ankerite). This basal conglomerate and breccia is succeeded by interbedded lenses of quartz-rich conglomerates and pink siltstones which grade into more than 50 m thick sandstones alternating with mudstones and siltstones (SOMMER, 1972). In the quartz-rich conglomerate chert clasts occur quite frequently and are derived from the reworked Devonian to Carboniferous sequence

below. The overlying intra-Permian volcanics, however, are missing in this sequence.

**Fossils:** No fossils have yet been found in this presumably continental sequence except some reworked conodonts in limestones pebbles of the conglomerates at the base.

**Origin, facies:** Sedimentologically, the Präbichl Formation represents three fining-upward megasequences with alluvial fan deposits at the base suggesting a braided alluvial channel system and a distal sheet flood facies (KRAINER & STINGL, 1986).

**Chronostratigraphic age:** Lower Permian (?).

**Biostratigraphy:** -

**Thickness:** At the type locality some 160 m, at other locations 50 to 100 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** The transgressive post-Variscan cover unconformably overlies different lithologies ranging from the Carboniferous Eisenerz Formation to Devonian limestones and the Upper Ordovician Blasseneck Porphyry (SCHÖNLAUB, 1982a).

**Overlying unit(s):** Werfen Formation (Triassic).

**Lateral unit(s):** -

**Geographic distribution:** According to KRAINER & STINGL (1986) the transgressive sequence at the base of the Northern Calcareous Alps in Salzburg (Leogang) and Tyrol (Wörgl) displays similar lithologies like the Präbichl Formation of the type area. A direct correlation, however, is not possible due to the lack of volcanics characterizing the intra-Permian volcanic episode and the break in the sequence in the type area obliterating the transition to the Werfen Formation. Similarly, to the east the Präbichl Formation can be recognized as far as the Semmering area although the abundance of basal breccias and conglomerates seems to be replaced by smaller-sized gravel bearing alluvial fan deposits (CORNELIUS, 1936, 1937; CLAR, 1972; SOMMER, 1972).

**Remarks:** -

**Complementary references:** -

### Kristbergschichten / Kristberg Beds

HANS P. SCHÖNLAUB

**Validity:** Invalid; the term was introduced by VAN AMEROM et al. (1982: p. 287) for a tripartite clastic sequence which unconformably overlies crystalline rocks of the Silvretta Phyllitgneissic Nappe in the Montafon region of Vorarlberg.

**Type area:** ÖK50-UTM, map sheet 1230 Bludenz (ÖK50-BMN, map sheet 142 Schruns), Außerkristberg north of Silbertal near Schruns, Vorarlberg (VAN AMEROM et al., 1982).

**Type section:** Creek between Bartholomäberg and Kristberg ("Profil Kristberg") of VAN AMEROM et al., 1982 (N 47°06'15" / E 09°57'49").

**Reference section(s):** -

**Derivation of name:** After locality Kristberg northeast of village Schruns in the Province of Vorarlberg.

**Synonyms:** -

**Lithology:** Clastic fluviomarine fining-upward megasequences consisting at the base of poorly sorted conglomerates

and breccias with clasts of the underlying basement rocks up to 30 cm diameter, succeeded by an alternation of greyish laminated and partly bioturbated sandstones and bedded and laminated siltstones with intercalations of up to 2 m thick blackish carbonate beds and capped by reddish alluvial fan deposits.

**Fossils:** Plants in the clastic beds and calcareous algae, ostracods, foraminifers and fish remains in the limestone beds.

**Origin, facies:** The lithology and fossil content of the whole sequence indicates short lasting marine incursions interrupted by a lacustrine environment favouring vegetation and the formation of caliches and paleosols.

**Chronostratigraphic age:** Upper Carboniferous (Stephanian) to Lower Permian (?).

**Biostratigraphy:** *Callipteris* sp. group *conferta*, *C. flabelliformis*, *Lebachia piniformis*, *L. parvifolia*, *Ernestiodendrum filiciformis*, *Odontopteris* sp. and others.

**Thickness:** At the type locality some 70 meters.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Crystalline Complex of Silvretta (granite gneisses).

**Overlying unit(s):** Gröden Formation.

**Lateral unit(s):** -

**Geographic distribution:** The Kristberg Formation is restricted to the Province of Vorarlberg and distributed between the Rellstal in the west and the Klostertal in the east extending laterally over some 15 km.

**Remarks:** -

**Complementary references:** -

### Silbersberg-Formation / Silbersberg Formation

FRANZ NEUBAUER

**Validity:** Invalid; first nomination by CORNELIUS (1952b: p. 51; "Silbersbergserie") with later descriptions by LESKO (1960), NIEVOLL (1984) and NEUBAUER et al. (1994).

**Type area:** ÖK50-UTM, map sheet 4212 Müzzzuschlag (ÖK50-BMN, map sheet 105 Neunkirchen), Eastern Greywacke Zone near Gloggnitz, Lower Austria.

**Type section:** The type locality of the Silbersberg Formation is at the southern slope of the Silbersberg near Gloggnitz (Lower Austria).

**Reference section(s):** -

**Derivation of name:** After mount Silbersberg near Gloggnitz (Lower Austria).

**Synonyms:** Silbersbergschichten (CORNELIUS, 1952a); Silbersbergkonglomerat (CORNELIUS, 1952a); Silbersbergserie (CORNELIUS, 1952b); Silbersbergschiefer (NIEVOLL, 1984).

**Lithology:** The Silbersberg Formation mainly comprises quartz-rich greyish-greenish metaconglomerates and quartzphyllites of variable composition ranging from quartz-rich to mica-rich phyllites interlayered with quartz-rich metaconglomerates. The areal extent was mapped by NEUBAUER et al. (1994). All rocks are metamorphosed in lower greenschist facies metamorphic conditions.

**Fossils:** -

**Origin, facies:** The rocks of the Silbersberg Formation are considered as terrestrial deposits at the margin of a depositional basin.

**Chronostratigraphic age:** Although originally considered as Ordovician or older (CORNELIUS, 1952b), the composition and macroscopic appearance remember that of the Permian Alpine Verrucano as already stated by NIEVOLL (1984). This was confirmed by <sup>40</sup>Ar/<sup>39</sup>Ar dating of concentrates of detrital white mica which yield an age of 359.6 ± 1.1 Ma implying a depositional age younger than the approximate Devonian/Carboniferous boundary (HANDLER et al., 1997).

**Biostratigraphy:** -

**Thickness:** Unknown.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** In nearly all cases a tectonic boundary including a sheared boundary to underlying Paleozoic quartzphyllite.

**Overlying unit(s):** Tectonic boundary.

**Lateral unit(s):** -

**Geographic distribution:** Lower Austria and eastern Styria.

**Remarks:** -

**Complementary references:** -

#### Graschnitz-Formation / Graschnitz Formation

FRANZ NEUBAUER

**Validity:** Invalid and informal unit; the term Graschnitz Formation was introduced on the ÖK50-UTM, map sheet 4217 Kindberg (ÖK50-BMN, map sheet 134 Passail) (FLÜGEL et al., 1990; erroneously named "Graschnitz-Formation" in the map's legend). Unfortunately, neither a description of the succession was ever published, nor explanatory notes for the map sheet.

**Type area:** ÖK50-UTM, map sheet 4217 Kindberg (ÖK50-BMN, map sheet 134 Passail).

**Type section:** No type section defined. A sort of type section is exposed along a long road cut north of Frauenberg village.

**Reference section(s):** -

**Derivation of name:** After the small village Graschnitz near St. Marein im Mürtal.

Remarks: The correct name of the small village in the Mürtal Valley SW of St. Marein is Graschnitz and not Graschnitz as misprinted in the legend of the map.

**Synonyms:** -

**Lithology:** Grey phyllites and other grey metaclastics of the Veitsch Group (not shown on ASC 2004) are overlain by reddish-grey metapsammitic and metapelitic rocks intercalated by quartz-rich metabreccias and acidic metatuffites. All rocks are metamorphosed in lower greenschist facies metamorphic conditions. In general, sand- and gravel-sized clasts display a reddish color. The lower boundary of the Graschnitz Formation is defined by a color change from grey phyllites to grey-reddish metaclastic rocks, which allows an easy separation from the underlying unit.

**Fossils:** -

**Origin, facies:** The Graschnitz Formation could be considered as a terrestrial deposit at the margin of a depositional basin.

**Chronostratigraphic age:** In Central Europe, the color change is commonly assigned to the approximate Carboniferous/Permian boundary, and the red colour is believed typical for Permian successions. A further argument for a possible Early Permian depositional age is the presence of several decimeter- to meter-thick layers of acidic metatuffites near the base of the Graschnitz Fm., which contain abundant volcanic quartz and K-feldspar phenocrysts. These layers are correlated with the Lower Permian Bozen Quartzporphyry.

**Biostratigraphy:** -

**Thickness:** Unknown.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Greyish, upper Carboniferous phyllites of a hitherto unnamed part of the Veitsch Group (not shown in the ASC 2004).

**Overlying unit(s):** Tectonic boundary.

**Lateral unit(s):** -

**Geographic distribution:** Veitsch Nappe of the Greywacke Zone in eastern Styria south of the Mürtal Valley (ÖK50-BMN, map sheet 134 Passail).

**Remarks:** -

**Complementary references:** -

#### Haselgebirge / Haselgebirge

KARL KRAINER

**Validity:** Invalid; informal term for multiphase deformed and weakly metamorphosed Permo-Triassic evaporites of the Northern Calcareous Alps (see MEDWENITSCH, 1951; KÜHN, 1962; TOLLMANN, 1976; SPÖTL, 1989).

**Type area:** Hallstätter Salzburg (Upper Austria), N 47°33'55" / E 13°37'54", ÖK50-UTM, map sheet 3217 Hallstatt (ÖK50-BMN, map sheets 95 Sankt Wolfgang im Salzkammergut, 96 Bad Ischl).

**Type section:** No type section defined.

**Reference section(s):** Poorly exposed on the surface, most studies are based on outcrops in saltmines of Hallstatt (Upper Austria), Hallein (Salzburg) and Hall (Tyrol).

**Derivation of name:** Old mining term (historical review in SCHAUBERGER, 1986).

**Synonyms:** Alpines Haselgebirge, Alpine Haselgebirge Formation.

**Lithology:** The Haselgebirge is a chaotic mélange of shale, siltstone, sandstone, anhydrite, carbonate and rare magmatic rocks embedded in a matrix of clayey halite. The mélange formed during severe tectonization caused by different tectonic processes during Alpine deformation (SPÖTL, 1989). Within undeformed Late Permian successions exposed in saltmines of Hallstatt (Upper Austria), Hallein (Salzburg) and Hall (Tyrol) SPÖTL (1988a, b, 1989) distinguished three lithofacies: (1) red beds and anhydrite, (2) nodular and stratified anhydrites, and (3) bedded halite.

**Fossils:** Pollen and spores, rare bivalves (KLAUS, 1953, 1963, 1965, 1972; SPÖTL, 1987).

**Origin, facies:** SPÖTL (1989) recognized three facies: (1) siliciclastic fan deltas and intercalated horizons of nodular and massive anhydrite, (2) small-scale shoaling upward anhydrite cycles which were probably overlain by primary sedimentary halite, and (3) intensively deformed halite. These sediments were deposited in a continental rift setting of the northwestern Tethys. Halite precipitated in a central salt pan, shoaling upward gypsum cycles developed in marginal sabkha-like flats surrounded by alluvial fans and mudflats (SPÖTL, 1988a, b, 1989).

**Chronostratigraphic age:** Late Permian according to S-isotopes (PAK & SCHAUBERGER, 1981; SPÖTL, 1987, 1988a, b) and sporomorphs (KLAUS, 1953, 1955, 1963). Early Triassic ("Scythian") age not proved.

**Biostratigraphy:** -

**Thickness:** 500–?1,000 m (SPÖTL, 1989).

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Präbichl Formation, Mitterberg Formation (not shown in the ASC 2004).

**Overlying unit(s):** Werfen Formation.

**Lateral unit(s):** Interfingers laterally with the Präbichl Formation and Mitterberg Formation (SPÖTL, 1988a, b, 1989).

**Geographic distribution:** Northern Calcareous Alps (Hallstatt, Bad Ischl, Hallein, Berchtesgaden, Halltal north of Hall in Tyrol).

**Remarks:** -

**Complementary references:** -

## Jungpaläozoikum von Zöbing / Lower Paleozoic of Zöbing

The Bohemian Massif achieved its paleogeographic position at the southern edge of the European craton during Variscan orogenic phases. During post-Variscan extensional tectonic processes sediments were deposited in NE–SW orientated basins. Most of these molasse-type sediments are known from subsurface occurrences; the only known 'post-Variscan transgressional deposit' outside the Alps in Austria is located at Heiligenstein – Geißberg area of the Waldviertel in Lower Austria (VASICEK & STEININGER, 1996, 1999).

### Zöbing-Formation / Zöbing Formation

HANS P. SCHÖNLAUB

**Validity:** Valid; the term was introduced by STEININGER & ROETZEL (2008: p. 50).

**Type area:** ÖK50-UTM, map sheet 4318 Langenlois (ÖK50-BMN, map sheet 38 Krems). Graben infill between the villages Zöbing am Kamp and Kammern including the mountain Heiligenstein and extending over some 6 km to Diendorf am Walde, Lower Austria.

**Type section:** To date no type section has been established.

**Reference section(s):** Several sections east of the river Kamp (see VASICEK, 1983, 1991; VASICEK & STEININGER, 1996).

**Derivation of name:** After the village Zöbing am Kamp in Lower Austria.

**Synonyms:** Jungpaläozoikum von Zöbing (VASICEK, 1991; VASICEK & STEININGER, 1999; STEININGER & ROETZEL, 2008).

**Lithology:** According to VASICEK (1977, 1991) the clastic sequence is divided into three members. The lowermost 300 m thick member comprises darkgrey laminated silt- and sandstones with coal-seams and limestone lenses and contains a rich flora known already in the 19<sup>th</sup> century and other fossils.

The middle member attains a thickness of some 500 m and consists of arkoses interbedded with thick conglomerate beds. The main components are granulites with pebble sizes of up to 1 meter, other clasts consist of quartz, marble, Gföhl gneiss and different volcanics.

The uppermost 300 m thick member consists of interbedded reddish siltstones and arkoses and ends with reddish, greyish and greenish mudstones with lenticular intercalations of sandstones and arkoses. Neither in the middle, nor in the upper member any fossils have been yet found and thus the exact age of these members is not known.

**Fossils:** Rich plant flora, gastropods, fish teeth and ostracods.

**Origin, facies:** The fossils reflect a lacustrine environment.

**Chronostratigraphic age:** Upper Carboniferous ("Stephanian") to Lower and Upper (?) Permian.

**Biostratigraphy:** Among others, rich occurrences of *Al-ethopteris zeilleri*, *Callipteris conferta*, *Ernestiodendron (Walchia) filiciformis* and *Reticulopteris germari* in the lower member.

**Thickness:** > 1,000 m.

**Lithostratigraphically higher rank unit:** -

**Lithostratigraphic subdivision:** -

**Underlying unit(s):** Crystalline Complex (granulites) of Bohemian Massif.

**Overlying unit(s):** No younger sediments are known.

**Lateral unit(s):** -

**Geographic distribution:** Extending some 6 km in southwest-northeast direction between the villages Zöbing am Kamp and Diendorf am Walde, Lower Austria. The graben-like structure has its maximum width of 2 km at the southern margin.

**Remarks:** -

**Complementary references:** -





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## Lithostratigraphische Einheiten / Lithostratigraphic Units

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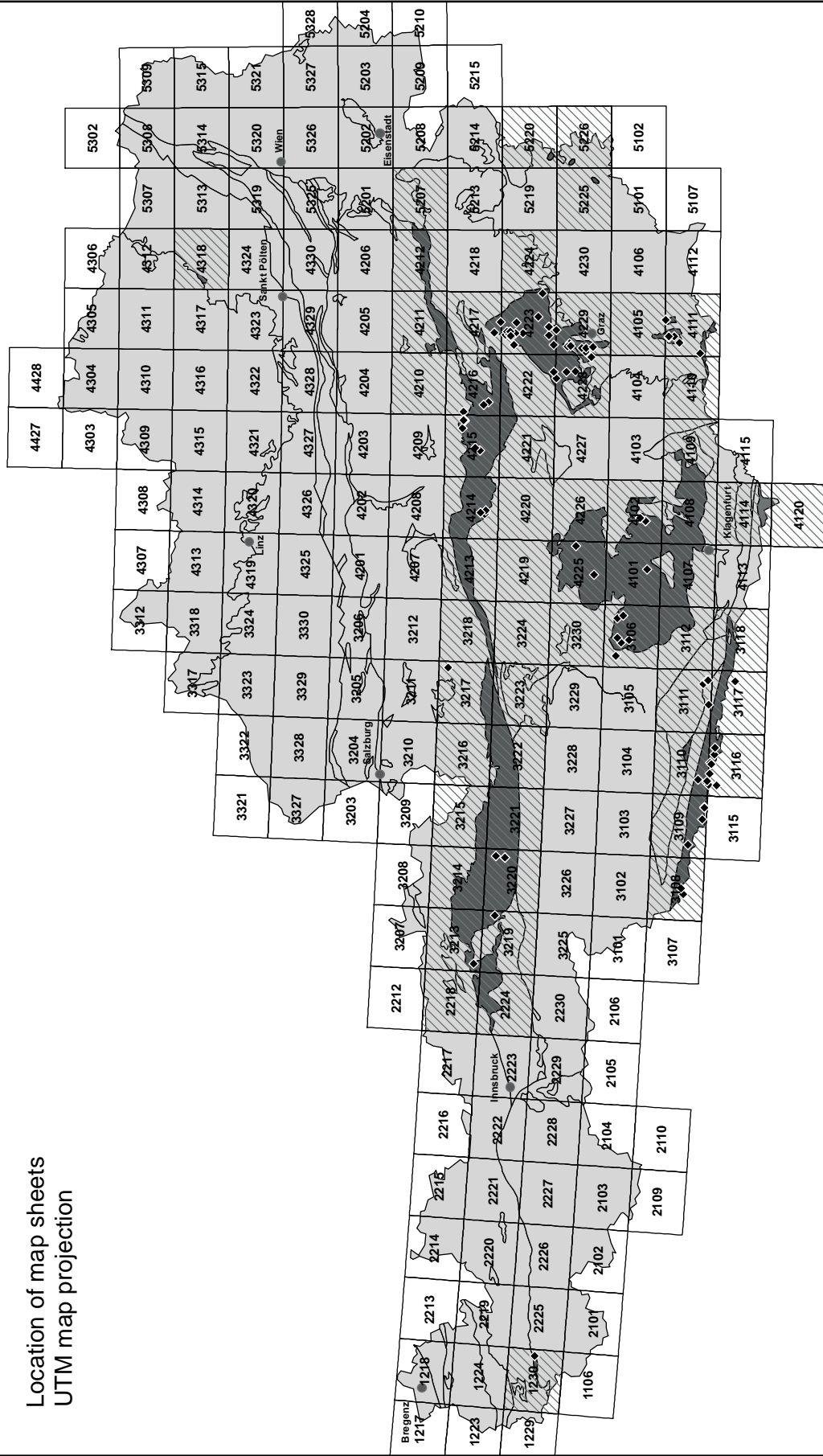
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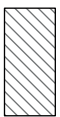
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### Appendix 1.

Location of map sheets  
UTM map projection



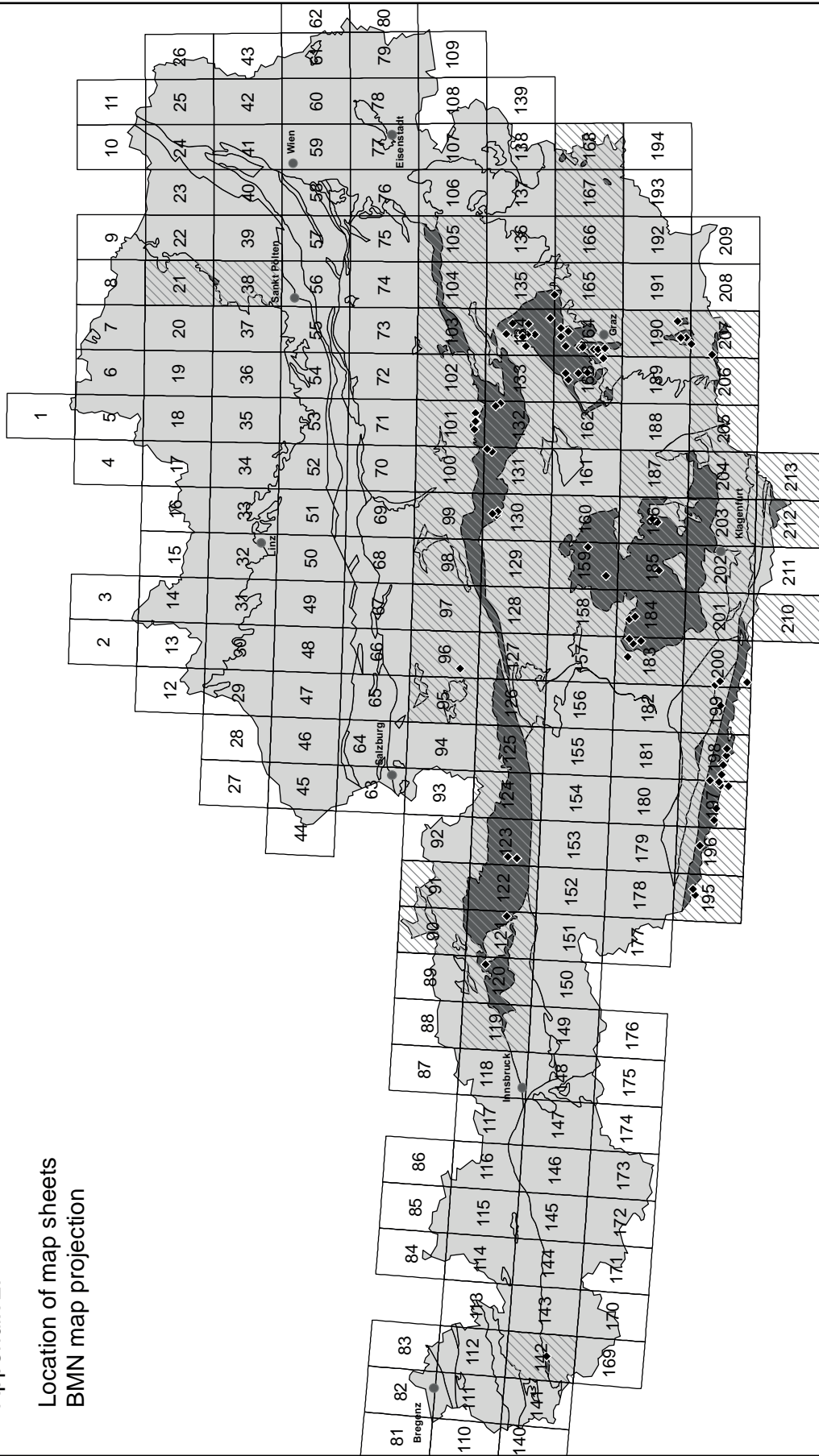
◆ Locations of type sections and type areas



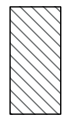
▨ Mapsheets containing paleozoic units according to the Stratigraphic Chart 2004

Appendix 2.

Location of map sheets  
BMN map projection



◆ Locations of type sections and type areas



Mapsheets containing paleozoic units according to the Stratigraphic Chart 2004



## thesaurus

<http://resource.geolba.ac.at/>

### **Thesaurus – a web based, controlled vocabulary of geoscientific terms as used by the Geological Survey of Austria.**

The thesaurus consists of concepts, as used by the Geological Survey of Austria. Each concept has its individual persistent web address (http) which allows the use as hyperlink, in web applications or for attributing geodata. Every concept in the thesaurus can have several labels like preferred or alternative (synonymous). The semantic context of each individual concept is illustrated by both hierarchical and non-hierarchical relations.

The content of the thesaurus is governed by an editorial team, which is supported by thematic experts on various topics. Current themes are constantly updated. All terms are available in German and for the most part in English.

Thesaurus-terms are published on the web in a machine-readable (XML, RDF, SKOS) format and are linked to other resources like Wikipedia, GeoSciML and Freebase.

The thesaurus can be used for free and meets the standards of the Semantic Web and Linked Open Data (LOD) initiatives. Programmatic data access is given via SparQL endpoints and REST interfaces.

With the creation of semantically and technically interoperable geodata-sets (for which the thesaurus serves as a semantic groundwork), the Geological Survey of Austria implements the legal requirements of the EU Directive 2007/2/EC (INSPIRE) and the corresponding Austrian law (GeoDIG). The thesaurus of the Geological Survey of Austria will thus be linked to INSPIRE terminology (and other internationally standardized vocabularies).

#### **governance & contact**

Thesaurus editorial team – Geological Survey of Austria – [thesaurus@geologie.ac.at](mailto:thesaurus@geologie.ac.at)

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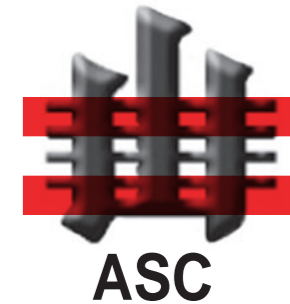
*Most of the content of this publication – The lithostratigraphic units of the Austrian Stratigraphic Chart 2004 (sedimentary successions) – Vol. 1 – The Paleozoic Era(them) – will be included in the Thesaurus.*



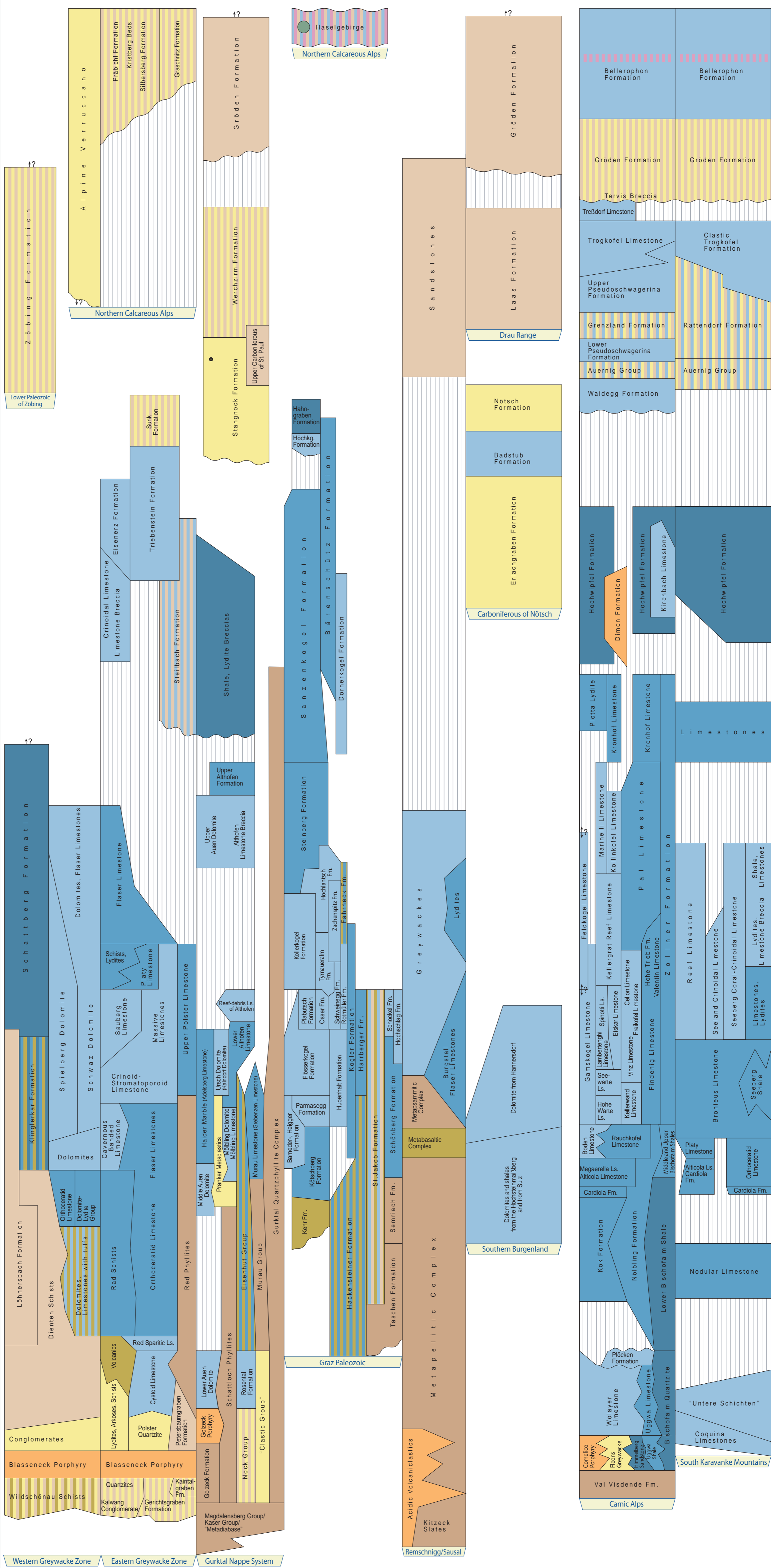
# Austrian Stratigraphic Chart 2004 - Paleozoic

(sedimentary successions)

Austrian Stratigraphic Commission



ERA	SYSTEM / PERIOD / SERIES / EPOCH	STAGE / AGE	DURATION Ma	Global Classification					
				ERATHM / ERA	SYSTEM / PERIOD / SERIES / EPOCH				
PALEOZOIC	PERMIAN	CHANGHSINGIAN / Dorashanian	251	PERMIAN	MID PERMIAN / GUADALUPIAN / LOPINGIAN				
		WUCHIAPINGIAN / Dzhulfian	255						
		CAPITANIAN	260						
		WORDIAN	265						
		ROADIAN	270						
		PERMIAN	LOWER PERMIAN / CISURALIAN			KUNGURIAN	275		
						ARTINSKIAN	280		
						SAKMARIAN	285		
						ASSELIAN	290		
		PERMIAN	TRIAS			GZHELIAN	295	TRIAS	U. CARBONIFEROUS / PENNSYLVANIAN
KASIMOVIAN	300								
MOSKOVIAN	305								
BASHKIRIAN	310								
TRIAS	LOWER CARBONIFEROUS / MISSISSIPPIAN			SERPUKHOVIAN	315				
				VISEAN	320				
				TOURNAISIAN	325				
PERMIAN	DEVONIAN			FAMENNIAN	350	DEVONIAN	UPPER DEVONIAN		
				FRASNIAN	355				
				GIVETIAN	360				
		EIFELIAN	365						
		DEVONIAN	LOWER DEVONIAN	EMSIAN	370				
				LOCHKOVIAN	375				
		PERMIAN	DEVONIAN	LUDFORDIAN / GORSTIAN	380			DEVONIAN	MIDDLE DEVONIAN
				HOMERIAN / SHEINWOOD	385				
				TELYCHIAN	390				
				AERONIAN	395				
RHUDDANIAN	400								
DEVONIAN	UPPER ORDOVICIAN			DARRIWILIAN	405				
				TREMA-DOCIAN	410				
PERMIAN	DEVONIAN			WEN-LUD-LOCK / LOW	415	DEVONIAN	LOWER DEVONIAN		
				HORNWATER / SHEINWOOD	420				
				TELYCHIAN	425				
		AERONIAN	430						
		RHUDDANIAN	435						
		DEVONIAN	UPPER ORDOVICIAN	DARRIWILIAN	440				
				TREMA-DOCIAN	445				
		PERMIAN	DEVONIAN	WEN-LUD-LOCK / LOW	450			DEVONIAN	LOWER DEVONIAN
				HORNWATER / SHEINWOOD	455				
				TELYCHIAN	460				
AERONIAN	465								
RHUDDANIAN	470								
DEVONIAN	UPPER ORDOVICIAN			DARRIWILIAN	475				
				TREMA-DOCIAN	480				
PERMIAN	DEVONIAN			WEN-LUD-LOCK / LOW	485	DEVONIAN	LOWER DEVONIAN		
				HORNWATER / SHEINWOOD	490				
				TELYCHIAN	495				
		AERONIAN	500						
		RHUDDANIAN	505						
		DEVONIAN	UPPER ORDOVICIAN	DARRIWILIAN	510				
				TREMA-DOCIAN	515				
		PERMIAN	DEVONIAN	WEN-LUD-LOCK / LOW	520			DEVONIAN	LOWER DEVONIAN
				HORNWATER / SHEINWOOD	525				
				TELYCHIAN	530				
AERONIAN	535								
RHUDDANIAN	540								
DEVONIAN	UPPER ORDOVICIAN			DARRIWILIAN	545				
				TREMA-DOCIAN	550				



- Legend**
- pelagic, offshore, siliciclastic
  - pelagic, nearshore, calcareous
  - shallow marin, neritic
  - terrestrial-continental, coarse clastic
  - terrestrial-continental, fine clastic
  - evaporite (chloride, sulphate)
  - rhyolite, dacite
  - (basaltic) andesite, trachyandesite
  - basalt
  - phyllite
  - mixed-facies (in corresponding colors)
  - coal (may include several seams)
  - ? position/age doubtful/controversial
  - | equal units
  - \ older unit left \ younger unit right
  - hiatus
  - unconformity
  - GSSP
  - Fm. Formation
  - Ls. Limestone

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