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The Sedimentary Record of North Penninic Schistes lustrés of the Lower Engadine Window and its Correlation to the Tauern Window (Eastern Alps)

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5 Text-Figures

Österreichische Karte 1 : 50.000
Blätter 144, 153, 170, 171, 172

Tirol
Unterengadin
Unterengadiner Fenster
Tauernfenster
Bündner Schiefer
Schistes lustrés
Stratigrafie
Kreide

Inhalt

Gliederung der nordpenninischen Bündner Schiefer des Unterengadiner Fensters und ihre Korrelation mit dem Tauernfenster (Ostalpen)

Zusammenfassung

Im Rahmen der Neukartierung des Fensterinnersten des Unterengadiner Fensters (Zone von Pfunds) wurden die bisher stratigrafisch ungegliederten Bündnerschiefer in 6 Formationen unterteilt. Basalte mit MORB-Signatur werden von Tuffiten mit Unterkreide-Alter überlagert. Der Kontakt zwischen Basalten und Tuffiten ist ein stratigrafischer. Die Tuffite gehen gegen Hangend in die Kalkschiefer des Neokoms über. Diese werden von der Tristelformation (Barrême bis Apt) überlagert. Die Tristelformation geht gegen Hangend wiederum in die Gaultformation (Apt bis Alb) über. Die Gaultformation wird von den Schwarzschiefern der Oceanic Anoxic Events (OAE) 1c und 1d der Fuorcla-d'Alp-Formation überlagert. Die jüngsten Sedimente der Zone von Pfunds werden durch die Malmurainza-Formation gebildet. Diese ist spätkretazischen Alters.

Sämtliche in der Zone von Pfunds des Unterengadiner Fensters etablierten Formationen konnten in der Glockner-Decke des Tauernfensters trotz der dort hohen Metamorphose von ca. 17 kbar und 600°C wiedergefunden werden. Da in beiden Decken eine ähnliche Struktur vorhanden ist und die sedimentären Abfolgen die gleichen sind, wird geschlossen, dass beide dem selben ozeanischen Becken (Valais, Nord-Penninikum) entstammen.

Abstract

Based on detailed stratigraphic work in the core region of the Lower Engadine Window (Zone of Pfunds) it was possible to establish a detailed stratigraphy of the schistes lustrés, dividing them into 6 formations. Basalts with MORB-signature are overlain by tuffites of Early Cretaceous age. They are overlain by calcschists of Neocomian age that grade into calcbreccias of Barremian to Aptian age (Tristel Formation). The Gault Formation of assumed Aptian to Albian age succeeds to the Tristel Formation. The Gault Formation is overlain by black shales (OAE 1c and 1d) of the Fuorcla d´Alp Formation. The youngest sediments of the Zone of Pfunds are represented by the Malmurainza Formation of Late Cretaceous age. All established formations of the Lower Engadine Window could be identified in the schistes lustrés of the Glockner nappe again although metamorphic conditions in the Tauern window are ca. 17 kbar at 600°C. As the sedimentary sequences in both nappes are the same, it is concluded that both orginate from the same oceanic basin (North penninic realm, Valais).

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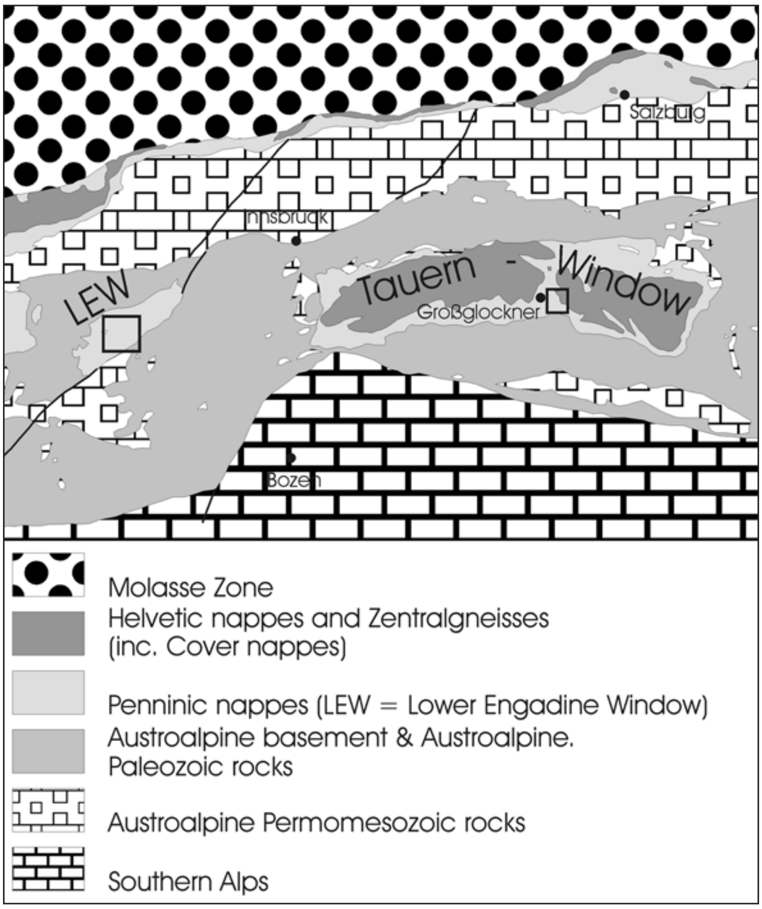
Text-Fig.1.
Tectonic overview of the western Eastern Alps.



1. Introduction

Within the Eastern Alps two large tectonic windows – the Lower Engadine Window in the western part and the Tauern Window in the middle part – expose Penninic units of the Western Alps.

In the Engadine Window which is situated at the Swiss-Austrian Border several Penninic tectonic units are exposed. They are overlain by the Austroalpine Basement and cover nappes of the Silvretta and Ötztal nappes (Text-Fig. 1).

The following Penninic realms can be identified within the Engadine Window (Text-Fig.2) – the Valais corresponding to the Zone of Pfunds in the core of the window, the Briançonnais exposed as the Tasna nappe in an intermediate position and the Piemontais represented by the Fimber unit, which represents also the highest tectonic unit (OBERHAUSER, 1980) of the Lower Engadine Window. The correlation of tectonic units to paleogeographic realms is based on the tectonic position of the nappes within the nappe stack and their typical sedimentary sequences. All units consist of basement rocks, which are of oceanic origin for the Valais and Piemontais and continental for the Tasna nappe and sedimentary cover rocks. The cover rocks range from Silurian to Eocene in the different nappes (e.g. BERTLE, 2002).

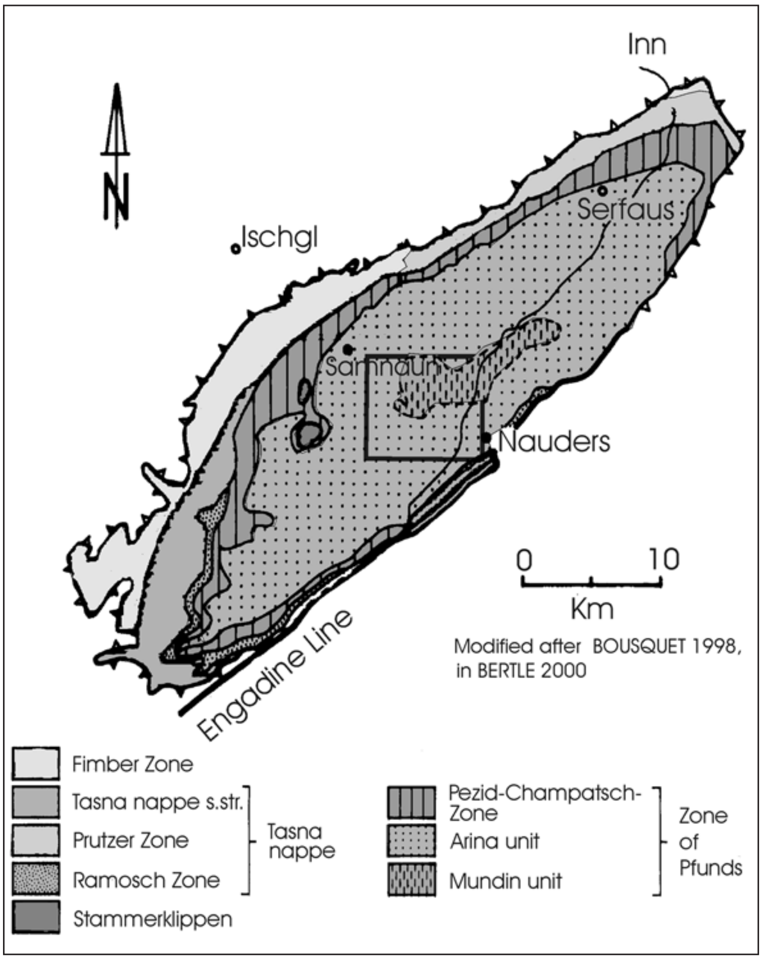
The Tauern Window further to the East (Text-Fig.1) exposes penninic units, but also helvetic ones. From bottom to top several tectonic units can be differentiated (Text-Fig.3):

- ❍ Zentralgneisses with their cover sequences (helvetic units, e.g. Venediger nappe of PESTAL et al. [1999]; FROITZHEIM et al. [1996])
- ❍ Seidlwinkel nappe (and melange) (sensu HÖCK & PESTAL, 1994) of continental (and oceanic?) origin (helvetic-penninic transitional unit)
- ❍ Glockner nappe s.str. of oceanic origin (ophiolites originating from a harzburgitic mantle, Valais trough [this work])
- ❍ Lower Austroalpine units (Matrei Zone?, Tarntal and Radstatt Mountains, e.g. TOLLMANN [1977])

This publication deals with the oceanic sequence of the Zone of Pfunds and its inferred correlation into the Glockner nappe of the Tauern Window. The correlation presented in this paper is based on bio- and lithostratigraphy combined with published geochemical data (KOLLER & HÖCK, 1990) from the ophiolitic remnants in the schistes lustrés of both tectonic windows.

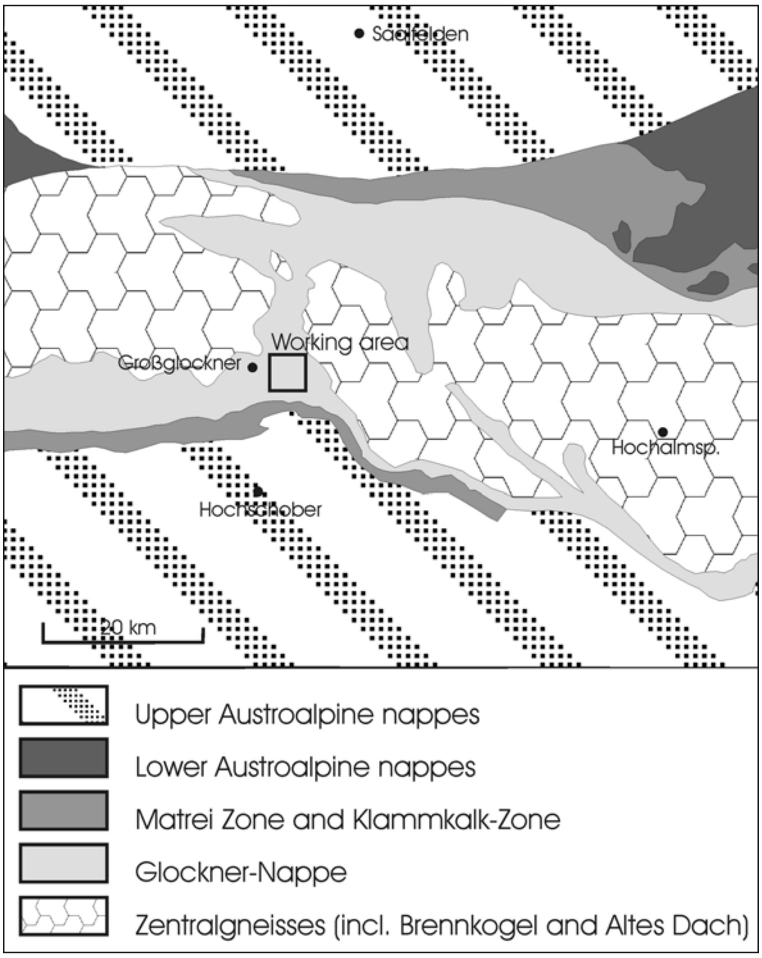
2. Existing Stratigraphic Data

The scarcity of stratigraphically useful fossils in the schistes lustrés is a long known fact (NABHOLZ & BOLLI, 1959), although it was possible to



Text-Fig. 2.
Tectonic overview of the Engadine Window, showing the Zone of Pfunds (Valais) in the deepest position within the window.

Text-Fig. 3.
Tectonic overview of the central Tauern Window.
Working area is marked by rectangle.



find some stratigraphic markers in the Western Alps (e.g. MARTHALER [1984]: cretaceous planctic foraminifera). However, in the case of the tectonic windows of the Eastern Alps there exist only micropaleontological data for the higher parts of the Zone of Pfunds (BERTLE, 1999, 2000) and of the Fimber unit (OBERHAUSER, 1983), and some spiculae were gained from calcschists of the Rechnitz Window S of Vienna (SCHÖNLAUB, 1973).

Until now in the Tauern Window no stratigraphically useful foraminifera or algae were found in the Bündnerschiefer. There exist only reports about sporen and pollen in phyllites of the northern Tauern Window (REITZ et al., 1990), indicating a Cretaceous age for these rocks.

3. New Data from the Lower Engadine Window (Zone of Pfunds)

In the core of the Lower Engadine Window in the region of Piz Mundin a large ophiolitic body is exposed. The basic rocks and the surrounding metasedimentary rocks were investigated for the first time by HAMMER in 1923. The metabasalts were investigated by HEUGEL (1975,1982). He described pillow basalts and characterized them geochemically as MORB. In 1998 BOUSQUET finished his thesis about structural and petrological investigations of the calcschists. He mapped the distribution of carpholite (an index mineral for HP-LT-metamorphism in carbonatic rocks; first description in the Lower Engadine Window by GOFFÉ & OBERHÄNSLI [1992]) and consequently defined the metamorphic conditions with 12 to 14 kbar at 380°C.

Mapping by the author of the Mundin region now revealed the presence of a turbiditic sequence of Cretaceous age (Text-Fig. 5). The age is indicated by rare findings of fossils and correlation of microfacies with fossil-bearing sequences within the tectonically higher portions of the Zone of Pfunds.

The base of the sedimentary sequence consists of metabasalts (Text-Fig. 4). The basalts occur as massive basalts, basic sills and as well developed pillow basalts and partly also pillow breccias. Oceanic metamorphism is indicated by veins filled with axinite or epidote/clinozoisite and green amphiboles at the rim of large magmatic pyroxenes. Blueschist facies overprint is indicated by glaucophane (BOUSQUET [1998], see also Text-Fig. 4), Na-Pyroxene and aragonite (BERTLE, 2004). At a few places it was possible to find metaradiolarites of probable early Cretaceous age, however stratigraphic data on the radiolarites are missing at the moment.

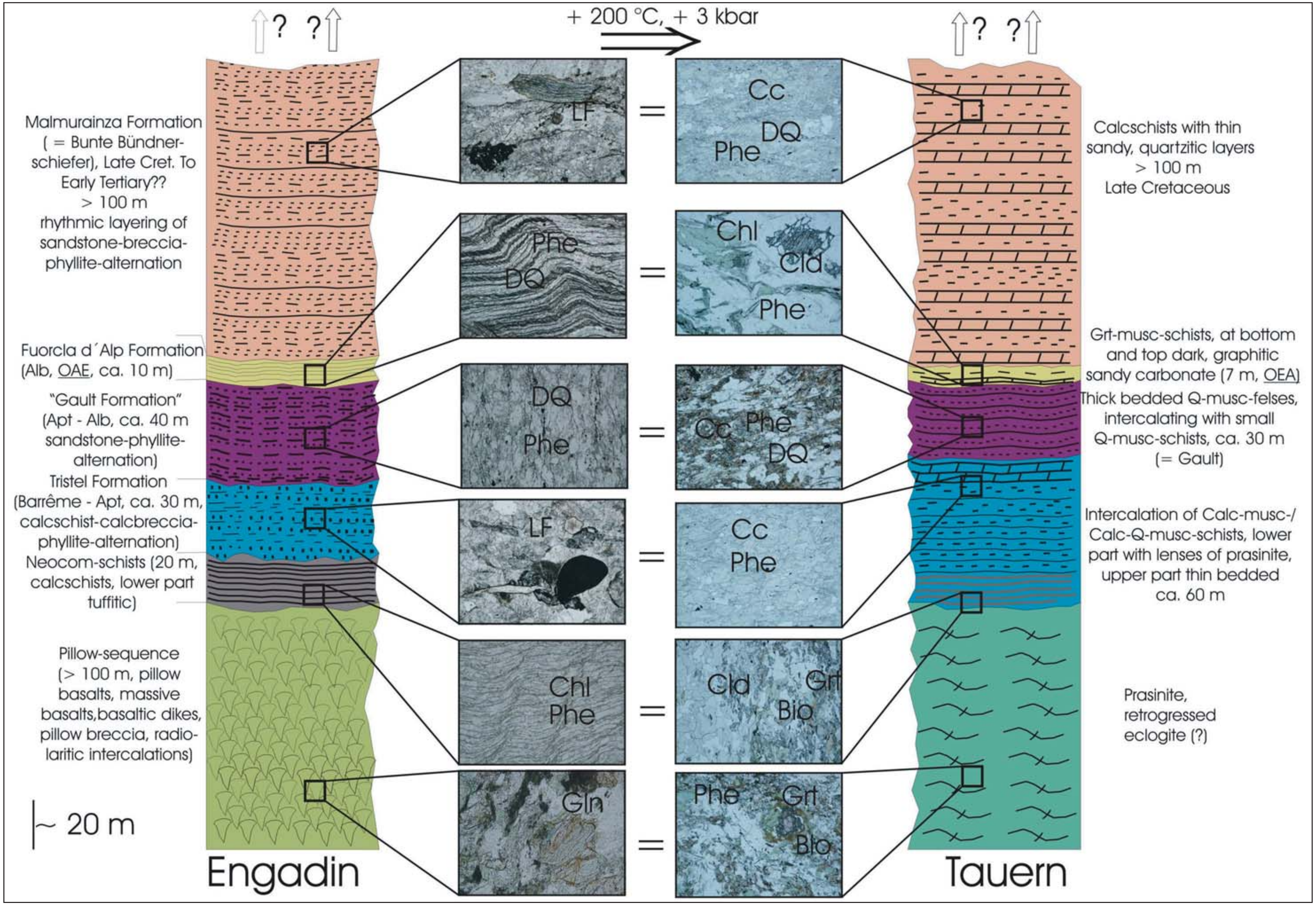
The metasedimentary sequence starts with tuffites. They consist of quartz, feldspar, white mica and chlorite and a large amount of carbonate. Carbonate rich layers intercalate with chlorite rich ones. The maximum thickness is about 5 meters.

In the upper part of the formation the amount of chlorite decreases so that the tuffites grade into pure calcschist of most probably early Cretaceous age ("Neocom schists"). They can be easily correlated with fossilbearing sequences of the Tasna nappe of the Lower Engadine window as both show similar lithologies.

The rather fine grained "Neocom schists" are overlain by the Tristel Formation (SCHWIZER, 1983; BERTLE, 1999, 2000, 2002, 2004). At Saderer Joch just east of Nauders the age of this formation is given by *Orbitolina* sp. and *Salpingoporella*. Further age constraints are given by new findings of *Neotrocholina fribourgensis* (GUILLAUME & REICHEL) at Saderer Joch confirming the age constraints of former fossil reports. The fossils mentioned above indicate at least a Barremian age of the sediments. At Piz Mundin it was possible to find *Quinqueloculina* sp. and cf. *Salpingoporella*. Sedimentary fabrics of the Tristel Formation point to a turbiditic origin of the sequence as already stated by SCHWIZER (1983). There exist also strong similarities to the Tristel Formation described by ALLEMANN (1956). Similar to the well know sequences at Piz Tasna (CADISCH et al., 1968; HESSE, 1973) the input of quartz grains increases while the carbonate clasts become scarce at the highest portions of the Tristel Formation.

Meanwhile the carbonate flysch grades into a quartzitic flysch: the "Gault Formation". This formation was well studied in the Tasna nappe of the Lower Engadine Window by HESSE (1973). The "Gault Formation" is overlain by 10 m of phyllitised black shales (= Fuorcla d´Alp Formation, BERTLE [2004]) of assumed uppermost early Cretaceous age corresponding most probably to an Oceanic Anoxic Event (OAE 1c and 1d, JENKYNS [1980]).

They are in turn overlain by a sedimentary sequence of turbiditic character: the Malmurainza Formation. It consists of a rhythmic layering of dark shales/phyllites and sandstones with some few intercalated coarse grained breccias. The age of the Malmurainza Formation is late Cretaceous in general, an early Tertiary age cannot be excluded, as the tectonically highermost part of the Zone of Pfunds is latest Cre-



Text-Fig. 4.
Possible stratigraphic correlation of sequences found in the Lower Engadine Window and the Tauern Window.
Phe = phengite; Cc = calcite/dolomite; Chl = chlorite; DQ = detrital quartz; Bio = biotite; Gln = glaucophane; Grt = garnet; Cld = chloritoide; LF = lithic fragments.
Pressure/Temperature increases from Lower Engadine Window to the Tauern Window with ca. 200°C and 3 kbar. All petrological investigations are based on P-T-calculations on phase equilibria. Thin sections demonstrate the different P-T-conditions of metamorphism by typical index minerals and textures/fabrics. So, for example, no garnet or chloritoide is found in the Lower Engadine Window.

taceous in age, indicated by *Lepidorbitoides* sp. and *Globotruncana* ex gr. *arca* (BERTLE, 1999).

Only at a few places (e.g. at Mutler) it was possible to find sediments rich in detrital mica, which show similarities to the Reiselsberg Formation (MATTERN, 1998, 1999) of the Rhenodanubic flysch zone of the Eastern Alps (TRAUTWEIN et al., 2001; EGGER, 1990, 1992; MATTERN, 1998, 1999) which is also of penninic origin (e.g. FAUPL & WAGREICH, 1992; OBERHAUSER, 1995).

4. New Data from the Tauern Window

Metamorphic overprint of the Tauern Window is distinctely higher than in the Lower Engadine Window, especially the thermal overprint. Recent investigations define the metamorphic peak conditions of metabasalts in the near neighbourhood of the area of investigation with 575°C and 17 kbar (DACHS & PROYER, 2001). Textures of metabasalts of the profile of investigation (Magneswand – Tafernigleiten – Schaflerloch NE of Franz-Josefs-Haus) show strong similarities to the metabasalts described by DACHS & PROYER (2001). Compared with the Lower Engadine Window there is an increase in metamorphic peak conditions of about 200°C and ca. 3 kbars (indicated in Text-Fig. 4). Stratigraphic data from the metasediments are still scarce. Although metamorphic overprint is much higher than in the Lower Engadine Window sedimentary structures (laminated bedding, detrital clasts, variations in whole rock bulk chemistry) are suprisingly well preserved. Fossil findings such as foraminifera, calpionellids or algae are not possible anymore as deformation and thermal overprint were apparently too intense.

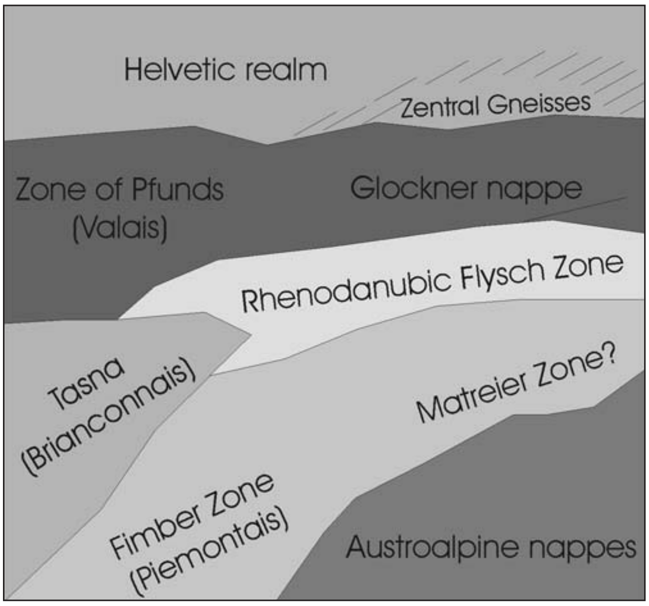
However, detailed investigation of the section revealed a very similar lithologic succession, which indicates a stratigraphy comparable to the Lower Engadine Window (Text-Fig. 4)

Basalts of oceanic origin – now metamorphosed under HP-conditions (indicated by garnet and glaucophane) – show primary contacts to tuffitic sediments. These tuffitic sediments grade into calcite-quartz-muscovite schists which exhibit a sedimentary layering resulting from a variation of the muscovite content. To the NE this sequence gradually changes into relatively pure calcschists which become more thin bedded in NE direction. Sometimes deformed clasts of dark color and small quartz grains can be found in the calcschists. The calcschists in turn are followed by thick bedded quartz-muscovite schists which show turbiditic characteristics. Strong similarities to the Gault Formation of the Lower Engadine window exist, e.g. similar composition, similar bedding. The next member is a dark calcschist of 5 m thickness with an extraordinary mineralogy (40 % Q, 20 % Chl & Phe, 20% Grt, 20% Cld). It becomes more quartzitic (sandy) and graphitic in the highest portion and is directly overlain by pure garnet-muscovite schists. The garnet-muscovite schists are bordered again by dark sandy and graphitic calcschists. Comparison with the Lower Engadine window shows, that the garnet-muscovite schists should represent the Fuorcla d´Alp Formation (black shales of Albian? Age).The last part of the cross section is made up of a sequence with rhythmic calcschist-quartzmetasandstone layering similar to the Malmurainza Formation.

5. Implications of New Stratigraphic Data

- In former times when no detailed stratigraphy of the Bündnerschiefer was available, the thickness of the Bündnerschiefer was estimated at 1.500 to 2.000 m (e.g. UCIK, 1966; THUM, 1966) which is significantly overestimated. Mapping of the different formations in the Engadine Window revealed a previously unknown large recumbent fold in the core of the Engadine Window in the region of Piz Mundin (BERTLE, 2004). The large recumbent fold of Piz Mundin demonstrates, that the outcropping Bündnerschiefer represent the result of large-scale isoclinal folding. Similar phenomena were described by LEMOINE & TRICART (1986) from the Bündnerschiefer of the Queyras area of the Western Alps in France. The described profile shows that a thickness of only about 500 m for the whole sedimentary sequence of the Bündnerschiefer of Cretaceous age is much more realisitic.
- Due to stratigraphic contacts of the basalts with the sediments, the area of HP-metamorphism in the Engadine Window is much larger than proposed by BOUSQUET et al. (2002). BOUSQUET et al. (2002) differentiated a nappe with carpholite occurrences from a higher nappe without carpholite and concluded that there is a large exhumation detachement inbetween. However the occurrence of carpholite strongly depends on the bulk chemistry of the primary sediment (pers. com. GOFFÉ [2002]). Mapping shows that the disappearence of carpholite corresponds to a change in the bulk chemistry of the rock, in our case represented by the transition from Neocom schists to Tristel Formation.
- Similar conclusions can be done in the Glockner region, where I expect that larger portions of the Glockner nappe suffered HP-metamorphism (of eclogite facies metamorphism) than previously assumed by several workers (e.g. DACHS & PROYER, 2001) who assumed that eclogite facies metamorphism of the Glockner nappe is restricted to the boundary of the Glockner nappe to the underlying Seidlwinkel and Venediger nappes (= “eclogite zone”). The possible widespread eclogite-facies metamorphism in the Glockner nappe is also indicated by many long known occurrences of lawsonite (e.g. FRANK et al., 1987).
- The new stratigraphic data support paleogeographic models showing the similarity of the Zone of Pfunds and parts of the Glockner nappe (Text-Fig. 5) as proposed e.g. by OBERHAUSER (1995). The theory of a continuous oceanic basin for the Bündnerschiefer of the Lower Engadine Window and the Tauern Window is also supported by the observation that no radiolarites of (assumed) Jurassic age can be found neither in the Zone of Pfunds nor in the Zone of Glockner Facies of the Glockner nappe. Field observations of sedimentary contacts between ultramafics (Heiligenbluter Serpentinit) and surrounding sediments in the Glockner region demonstrate that the sedimentary succession covering the ultramafics exhibits no radiolaritic rocks or palombini-like sediments as it should be expected for rocks of South penninic origin (e.g. TOLLMANN, 1977, 1987; WEISSERT & BERNOULLI, 1985). Assuming a deposition of the Bündnerschiefer of the Lower Engadine Window and the Glockner nappe in one single oceanic basin, the Zentralgneisses of the Tauern Window become tectonic units of the Helvetic realm as proposed e.g. by FROITZHEIM et al. (1996). There would be no Briançonnais in the Tauern region as it can be defined in the Swiss Central alps (contrary opinions see e.g. NEUBAUER et al. [2000] or FAUPL & WAGREICH [1992]). In my opinion the Briançonnais basement ends in the region of Nauders at the southern boundary of the Lower Engadine Window (map in BERTLE in prep.) as indicated by the disappearence of the Tasna basement and its typical sedimentary cover. For instance, further to the East no members of the typical Briançonnais cover like the couches rouges of Late Cretaceous to Tertiary age (e.g. OBERHAUSER, 1980) can be found.
- The detailed relationship of the Bündnerschiefer of the Zone of Pfunds to the Rhenodanubic Flysch Zone is not

clear at the moment, however, based on the occurrence of Early Late Cretaceous sediments rich in detrital mica, a correlation using the Reiselsberg Formation seems to be possible. As shown by MATTERN (1998, 1999), sediment transport within the Reiselsberg Formation was from S (SW?) to N (NE?), like in the older "Gault" and Tristel Formations (HESSE, 1972; SCHWIZER, 1983). The Rhenodanubian Flysch Zone therefore can be situated in between the continental ridge of the Briançonnais realm and the sedimentation region of the Zone of Pfunds or in a position just N of the Zone of Pfunds (Text-Fig. 5). The paleogeographic position presented here is similar to the one of OBERHAUSER (1995) or BERTLE (1999). The proposed model would also be in concordance with the model of MATTERN (1998), who proposes a similar position for the Rhenodanubic paleogeographic realm for the region of the Lower Engadine Window. It further allows to explain the input of heavy minerals with alpine metamorphic history as it was demonstrated by TRAUTWEIN et al. (2001) for the middle and eastern parts of the Rhenodanubic Flysch Zone. The mentioned authors conclude, that the heavy minerals of the Reiselsberg Formation of the Tauern transect should orginate from the Austroalpine nappes as the FT-ages of the heavy minerals are Mesozoic (mainly Cretaceous).



Text-Fig. 5.
Paleogeography for the Early Late Cretaceous.
The Rhenodanubic realm is situated just North of the Briançonnais (Tasna nappe) in the Western part of the Eastern Alps and in a central to southern position within the oceanic basin in the Tauern area further to the East. Sediment transport in the Rhenodanubic is generally from south to north and from west to east during the Early and Early late Cretaceous as indicated by paleocurrents of the Tristel, Gault and Reiselsberg Formations. The schistes lustrés of the Lower Engadine Window are situated north of the Rhenodanubic realm as indicated by the reduced thickness of the formations mentioned above. The schistes lustrés are therefore interpreted as a more distal flysch. The Matreier Zone might be the eastern continuation of the Piemontais.

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