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ZUR GEOLOGIE DES PIZ MUNDIN-GEBIETES (ENGADINER FENSTER, ÖSTERREICH-SCHWEIZ): STRATIGRAPHIE, GEOCHRONOLOGIE, STRUKTUREN

von

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This thesis represents a completely new investigation of the region between Samnaun und Reschenpass at the Austrian – Swiss border. The whole region was mapped in a scale of 1 : 10.000. This thesis presents the first mapping of this region since HAMMER (1923). Mapping was combined with detailed petrological-geochronological and micropaleontological investigations of the outcropping rocks.

The working area can be divided into two main units: the penninic units of the Engadine Window and the frame consisting of the Austroalpine nappes. The frame is made up by the Silvretta nappe, which reduces its thickness from W to E. The Ötztal nappe overthrusts the Silvretta nappe along the Schlinig fault. W-directed overthrusting took place during the Cretaceous. Later the fault was reactivated as a east-directed normal fault. Thrusting along the Schlinig fault resulted in ductile carbonate mylonites in mesozoic sediments of the Engadiner Dolomiten just below the thrust. In this mylonites calcite is deformed in a ductile way whereas dolomite reacts brittle. Therefore the mylonite consists of a ductile calcite-matrix in which brittle deformed dolomite clasts are enbedded. The exact trace of the Schlinig fault was unknown in the region of Piz Lad until now. New mapping showed that the mesozoic sequence of Piz Lad rests above biotite-paragneisses (type Plamort).

Thrusting of the Ötztal nappe over the Silvretta nappe resulted in diaphtoreses of the basement rocks of the Silvretta nappe: feldspar and biotite break down to chlorite and growth of white mica in the sediments of the Engadiner Dolomiten is observed. The age of thrusting and related metamorphism in the Austroalpine nappes is Cretaceous in age, proofed by geochronological dating. The Silvretta nappe itself is thrusted upon the Engadine Window along a highly ductile calcmylonite.

The Engadine window of the working area consists of the Middle Penninic Tasna nappe and the deeper Zone of Pfunds of North Penninic (Valais) origin. Structural imprint of the penninic units is much younger than that of the Austroalpine nappes as indicated by fossils and geochronological data from the penninic units.

The Tasna nappe shows a reduced sequence compared to its type locality further in the W. It is built up of a basement which crops out as a crust-mantle-boundary. This contact can be studied very well near Mot and Plattamala:

Ultramafics of lherzolitic composition (with preserved olivine, clinopyroxene and orthopyroxene) are overlain by small discontinuous lenses of gabbro. A few outcrops also show small basaltic dikes within the ultramafics. Along a transitional contact banded amphibolites border the ultramafics and gabbros. The amphibolites grade into the acid and less deformed Tasna granite. Sometimes schlieren-type to intrusive contacts of gabbroic rocks to granites can be observed. A metamorphic overprint of the ultramafics is indicated by the occurrence of older pargasitic hornblende (Al_2O_3 up to 14 %) and later actinolitic-tremolitic amphiboles which are found in joints. Within the ultramafics retrograde garnet peridotites can be found. The retrograde peridotites are characterized by symplectites of green spinell and pyroxene, indicating that the rock was probably a garnet peridotite, that was metamorphosed at about 900°C and 16 kbar. Discordant basaltic dikes and small gabbro lenses within the ultramafic body of Nauders show within-plate signatures in the geochemical charakteristics. A very special ultramafic rock in the core of the occurences shows the paragenesis of large hercynite (up to more than 1 cm size) rimmed by epidote?, pyroxene, kaersutite, phlogopite and an unidentifyable symplectite.

The sedimentary cover of the Tasna nappe is very reduced in the working area. Relics of Steinsberg limestone (crinoid-belemnite-limestone of lower liassic age) rest directly on ultramafics, in some parts also Tristelformation and Gault formation (lower Cretaceous) can be found.
The imprint of regional metamorphism in the Tasna nappe is difficult to assess. Green amphiboles in joints of the serpentinites, breakdown of feldspar of the Tasna granite (feldspar reacts to chlorite, albite, epidote, tremolite and questionable pumpellyite) as well as growth of stilpnomelane in the latter indicate lower greenschist-facies overprint during alpine time. In joints of diorite type rocks blue amphibole was observed.

Until now a detailed stratigraphic sequence of the undifferentiated Graue Bündnerschiefer of the Zone of Pfunds was missing. During the mapping campaigns of this thesis 6 formations could be distinguished:
The oldest sediments that crop out are radiolarites of upper Jurassic to lower Cretaceous age, which can always be found in stratigraphic contacts to the blueschist-facies basalts of Piz Mundin. In most cases however the basalts are overlain by the tuffitic transition member which itself grades into the Neokomschiefer. This transistion is given by reduction of the chlorite content of the sediment from bottom to top and increasing carbonate content of the rock at the same time. The Neokomschiefer grade into the Tristelformation which is of Barremian to Aptian age as indicated by foraminifera and dasycladales. *Neoctrocholina fribourgensis*, orbitolinids and *Quinqueloculina* sp. are found at the Saderer Joch, dasycladales and *Quinqueloculina* sp. as well as questionable *Orbitolina* sp. at Piz Mundin. Both indicate a lower Cretaceous age of the sediment. Decreasing carbonate content and simultaneous increase of the amount of quartz clasts are typical for the gradational part of the Tristelformation to the stratigraphically higher Gault formation. The Gault formation is a turbiditic sequence characterized by the rhythmic change of quartz sandstones layers and dark phyllite layers. At the base of the Gault formation single layers of Tristelkalk are intercalated.

The Gault formation is overlain by the Fuorcla d´Alp formation which represents black shales of probable Albian age (max. age R. *appeninica* zone). The age of the black shales is defined by lithostratigraphic comparision with the nonmetamorphic and fossiliferous sequence of the helvetic units of Vorarlberg. The youngest part of the stratigraphic column at Piz Mundin is represented by the Malmurainza sequence. It is a turbiditic sequence of upper Cretaceous to lower Tertiary age. The sandstones show highly variable composition: pure calc sandstones can change with pure quartz sandstones as well as with sandstones containing blonde dolomite clasts and gneissic clasts. Parts of the Malmurainza sequence which show strong input of detrital mica may correspond to the Reiselsberg sandstone (Cenomanian to Turonian) of the Rhenodanubic realm. Taking this comparision in consideration the paleogeographic position of the Rhenodanubic realm would be in between the Piz Mundin ophiolite in the north and the Tasna nappe in the south.
The Roz brecia may represent the youngest parts of the Malmurainza sequence and is of upper most Cretaceous age as indicated by reworked Orbitoides sp. and Globotruncana arca.
In the field where no difference between the formations was visible due to unfavourable intersection of schistositiy and topography only Graue or Bunte Bündnerschiefer were mapped.

The rocks of the Zone of Pfunds suffered HP-LT-metamorphism, the retrograde path was reconstructed using petrological methods:
Bündnerschiefer in the region of Piz Mundin are characterized by the HP-paragenesis of carpholite – phengite. Overprint of greenschist facies grade resulted in the break down of carpholite to chlorite and in the growth of a phengitic rim with lower Si-content around phengite I. Radiolarties contain the HP-paragenesis jadeitic pyroxene – blue amphibole.
Basalts and ophicarbonates are characterized by the following HP-paragenesis:

Jadeitic clinopyroxene – aragonite – blue amphibole – stilpnomelane.

The following greenschist facies overprint is defined by actinolite – epidote/clinozoisite – chlorite and pumpellyite (partly these minerals were also produced during oceanic metamorphism before the HP-event).
Geothermobarometric calculations resulted in:

P_{min}	=	ca. 10 kbar and T = 350°C (Jadeite)
P	=	13 kbar and T = 375°C (Carpholite)
P	=	7.5 kbar and T = 375°C (Aragonite)
T_{max}	=	ca. 400°C (Stilpnomelane)
T_{max}	=	380 °C (Carpholite)

The cross cutting veins of the basalts are characterized by quartz, calcite, feldspar and axinite which is missing in veins in the Bündnerschiefer. Axinite was only visible at Piz Mundin. Fluid inclusion investigations in quartz helped us to define the low grade evolution of the metamorphic path. The fluid inclusions (FI) investigations resultet in:

Vein quartz from the Piz Mundin was suprisingly rich in FI. At the base of the vein quartz at the contact to the host rock (blueschist) epidote-clinozoisite cristalls are visible. Futhermore amphibole is visible. It is common at the base of the vein quartz and decreases towards the middle of the vein. FI occure as H_2O-rich FI indicating high pressure of trapping.

Quartz from the upper most part of the Zone of Pfunds from S of Zeblasjoch (W of Samnaun Dorf) shows two main groups of primary FI could be differentiated at room temperature: homogenous FI and such with a bubble. All FI were frozen at max. temperatures of ca. –56°C. Bigger FI show cracking due to crystallisation pressure (build up of wings), the cracks however closed again during heating, so that the FI remained closed. Initial melting started between –20°C (first recrystallisation signs) and –9°C, final melting was observable at –1°C to 0°C. Then the FI was a.) homogenous or b.) showed a bubble. Homogenisation Temp. of the inclusions with bubble were in the range of 70 to 100°C , most of them between 70 and 80°C. The data indicate a more or less pure H_2O-system for the FI under high pressure. Assuming a crystallisation temperature of the crystalls of about 200 to 250°C and a density of the FI between 0.97 and 1.0 g/cm^2 pressures of 2.5 to 4.5 kbar are indicated for the time of trapping of the fluids.
The same P-T-conditions (same chemistry and melting & homog. Temp.) could be derived from FI in quartz from the Salaaser Kopf (Idalpe) for the late metamorphic evolution of the Fimber unit.

The reconstructed metamorphic evolution of the Piz Mundin area shows all signs of a very cool pressure-dominated subduction-related metamorphism. The reconstructed P-T path is similar to the well known ones of Crete and the San Franciscan complex.
The metamorphic overprint of the penninic units was dated using different geochronological methods: It was tried to date carpholite using the Sm-Nd-method. Unfortunately the spread of the mineral concentrate was too low to calculate a reasonable age.
The blue amphiboles were dated using the Ar-Ar-methode. However dating resulted in Ar-excess-ages of no geological significance. Ar-ages range within ca. 30 and ca. 47 Ma within the Zone of Pfunds and show a complex pattern of regional distribution. It is interestingly to note, that all age spectras with plateau ages show older ages in the high-temperature-steps of the Ar-release diagram. Ar-plateau age of amphibole from the crust-mantle-boundary at Mot is ca. 185 Ma.

Rb-Sr dating of white mica from the Bündnerschiefer and the tuffitic transistion member resulted in ages between 26 and 37 Ma. The metamorphic ages gained from the micas of the tuffitic transistion member may be correlated with the HP-event. Whole rock thin slab investigations of blueschists with the Rb-Sr-method did not allow to calculate age as spread of the different lithologies was too small.
Fission track dating gives us some information about the late exhumation and cooling stages of the penninic units. One sample from Piz Malmurainza resulted in 48 Ma for zircon, one sample from Nauders also in 48 Ma for zircon. Thus the FT-ages of zircon are older then micas dated with Ar-Ar from nearby localities. It can be concluded, that subduction and exhumation of the schistes lustrés was very fast.

In the presented paleogeographic reconstruction the Zone of Pfunds is located in the North penninic realm (Valais). The Brianconnais (Tasna nappe) is located south of the Zone of Pfunds. Based on stratigraphic and sedimentological arguments the Rhenodanubic realm is located N of the Zone of Pfunds. Its detrital input mainly originates from the W and N. Because of stratigraphic, sedimentological and tectonic arguments the Glocker nappe of the Tauern window is also located within the North penninic realm and correlated to the Zone of Pfunds. A Middle penninic realm (Brianconnais) does not outcrop or did not exist in the Tauern realm. The paleogeographic position of the Rhenodanubic realm in the Tauern section is not clear at the moment.