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TECTONOMETAMORPHIC EVOLUTION OF THE AUSTROALPINE NAPPES IN THE NORTHERN ZILLERTAL AREA, EASTERN ALPS, TYROL

by

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Abstract

In the frame of the TRANSALP project, this investigation addresses the tectonic evolution of the Austroalpine nappes in the northern Zillertal area (Tyrol). The units to be studied in the course of this investigation are the Kellerjochgneiss (Schwazer Augengneiss), the Innsbruck Quartzphyllite and the Wildschönauer Schiefer. The Innsbruck Quartzphyllite is part of the lower Austroalpine units and the Kellerjochgneiss is still of debated origin, since over the years it has been attributed to either the lower- or the middle Austroalpine units. The Wildschönauer Schiefer is part of the upper Austro Alpine units. The Innsbruck Quartzphyllite and the Kellerjochgneiss show an Eo-Alpine metamorphic overprint under low- to high greenschist facies conditions. The Wildschönauer Schiefer was affected by low greenschist facies conditions. The lithological units are separated by relatively small shear zones, ranging from less than a meter in diameter up to several meters. The Kellerjochgneiss, which is an ortho-augengneiss, contains the mineral assemblage muscovite + biotite + albite + chlorite + quartz ± stilpnomelane. In addition, a pegmatite sample in the Kellerjochgneiss contains the assemblage garnet1 ($Alm_{68}Spess_{27}Pyr_{3}Gro_{2}$) + garnet2 ($Gros_{52}Alm_{33}Spess_{15}$) + biotite + stilpnomelane + muscovite + chlorite + albite + quartz. Due to the discontinuous chemical zoning of the garnets this probably represents a remnant of an earlier metamorphic (possibly Permian or Variscan) event. Within the Innsbruck Quartzphyllite greenschist-layers of a few meters in diameter appear. This metavolcanic rocks contain the mineral assemblage albite + chlorite + muscovite + clinozoisite + sphene + calcite + stilpnomelane ± ilmenite ± biotite.
Thermobarometry in the samples of the Kellerjochgneiss was performed by calculating invariant points with multi-equilibrium methods such as THERMOCALC v. 2.7 with the data base of HOLLAND & POWELL (1998) and TWEEQU v. 1.02 with the data base of BERMAN (1988) and MASSONNE (1997). In addition the empirically calibrated muscovite + chlorite + stilpnomelane + quartz thermobarometer by CURRIE & VAN STAAL (1999) was also applied. For the quartzphyllite samples only the program THERMOCALC v. 2.7. was used.

The calculations with THERMOCALC v. 2.7. with the assemblage muscovite + biotite + chlorite + albite + quartz ± clinozoisite, constrain an invariant point in the KNaMASH-system, which yields pressures ranging from 4.0 to 11.0 kbar and temperatures ranging from 242 to 408°C. This invariant point also involves H_2O, which is unconstrained yet. Calculations with varying $a_{(H2O)}$ from 1.0 to 0.1, only result in a slight shift in pressure of ca. 1 kbar. The calculations with the program TWEEQU 1.02 with the data base of BERMAN (1988) using the same mineral assemblage but without the celadonite component, which is not included in the data base BERMAN (1988) yields an additional invariant point. Additional invariant points were also calculated with the data base of MASSONNE (1997) which also includes Fe-stilpnomelane and phengite. Overall, these calculations yield pressures ranging from 4.6 to 10.25 kbar and temperatures ranging from 273 to 428°C. The results achieved with the empirical thermobarometer of CURRIE & VAN STAAL (1999) are in good agreement and yield pressures ranging from 5.8 to 7.5 kbar and temperatures ranging from 310 to 400°C.These high pressures are still consistent with the absence of jadeite at temperatures between 350–400°C (HOLLAND, 1980). In the Innsbruck Quartzphyllite, due to the absence of biotite, it was only possible to calculate a reaction among muscovite, chlorite and albite. The calculations with THERMOCALC v 2.7 yield the reaction: 6Paragonite + 5Celadonite = 5Muscovite + 6Albite + Clinochlore + 2Quartz + $2H_2O$, which was used to estimate the pressures. The average pressures lie at 4.8 ± 1.2 kbar and the average temperatures yield 288 ± 73°C.

The interpretation of the widespread of the thermobarometric data of the Innsbruck Quartzphyllite and the Kellerjochgneiss is difficult, because of polyphase metamorphic overprint under greenschist facies conditions of both units. There may be two different scenarios:
A: The thermobarometric data expose a mixture of two metamorphic stages, where the first might be a pre-Alpine event (Variscan or Permian) with low pressures and the second might be an Eo-Alpine overprint with high pressures.
B: The thermobarometric data reflect an Eo-Alpine event with high pressures of > 6 kbar and a strong retrograde overprint which affects the rocks of the Kellerjochgneiss to various degrees.

In addition detailed field mapping of an area of ca. 50 km^2 in the northern Zillertal was performed and the structural data were compared to the previous structural observations of ductile and brittle deformation from these units and also the adjacent units such as the Northern Calcareous Alps (SCHMIDEGG, 1964; ROTH, 1983; EISBACHER & BRANDNER, 1995; ORTNER & SACHSENHOFER, 1996; STEYRER et al., 1996; KOLENPRAT et al,. 1999; ORTNER et al., 1999; REITER, 2000; GRASBON, 2001).
The observations suggest the following tectonic evolution of the Innsbruck Quartzphyllite, the Kellerjochgneiss and the Wildschönauer Schiefer: Six stages of deformation could be distinguished in the units whereas the first five stages (D1–D5) are ductile, and the last stage (D6) took place in the brittle regime. The first stage (D1) is associated with relict deformation structures of a possible Pre-Alpine (Variscan or Permian) event. The second stage (D2) is the result of the NW–SE oriented compression and isoclinal folds and shear bands indicate a transport top to W–NW. The third stage (D3) is manifested through narrow to open folds indicating a NE–SW oriented contraction. The fourth stage (D4) is also characterized by open folds and a penetrative axial plane foliation which is the result of NNW-SSE oriented compression. During the last ductile stage (D5) semiductile kink bands form.

The structures related to D5 are interpreted to be associated with the beginning uplift of the Tauern Window. The subsequent brittle deformation (D6) can also be divided into four stages (D6a-d). The earliest stage is the result of a NW-SE contraction. The following stage is characterized by brittle faults indicating an NE-SW contraction. Faults of the third stage are the result of an E–W extension. The youngest stage is related to a N-S compression. Overall, the obtained deformation sequence is in agreement with the two-stage Alpine geodynamic evolution model of NEUBAUER ET AL. (2000).

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