Eine detachment Falte am westlichen Ende der SEMP - Ergebnisse aus der geologischen Vorerkundung für den Brenner Basis Tunnel

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Die Ahorn Scherzone ist Teil jenes Störungssystems, welches im westlichen Tauernfenster an die Salzach-Enns-Mariazell-Puchberg-Störungszone (SEMP) anschließt und deren sinistralen Versatz nach W hin aufnimmt. Die Hauptstörungen dieses Störungsystems verlaufen an den Rändern der einzelnen, in ENE-WSW-Richtung gelängten Zentralgneiskerne. Es gibt verschiedene Modelle hinsichtlich des kinematischen Zusammenhangs der sinistralen Störungen mit der SEMP: Diskutiert werden sowohl ein Aufspleißen der SEMP in mehrere ENE-streichende Teiläste (FRISCH et al. 2000, LINZER et al. 2002), als auch ein System en-echelon angeordneter ENE-streichender Störungen und damit im Zusammenhang stehende aufrechte Falten (ROSENBERG & SCHNEIDER 2008). Im letzteren Modell stehen die Störungen nicht direkt in Verbindung (wohl aber kinematisch), und die Ahorn-Scherzone stellt allein die westliche Fortsetzung der SEMP dar; dabei wird der sinistrale Versatz an der Ahorn Scherzone im W durch aufrechte Falten mit ENE-streichenden Faltenachsen kompensiert. Aufbauend darauf stellen wir ein etwas abweichendes Modell vor, wo der sinistrale Versatz der Ahorn Scherzone in einer großen detachment Falte mit einer nach W abtauchenden Faltenachse kompensiert wird. In der detachment Falte, die auch als Schöberspitzen Antiform bezeichnet wird, werden Gesteine der Unteren Schieferhülle - i. W. des Hochstegen Marmors - von ihrem Untergrund - dem Zentralgneis - abgeschert und aufgefaltet. Die nach W abtauchende Faltenstruktur in der Schieferhülle verläuft dabei schräg über den Nordschenkel des Tuxer Zentralgneiskerns, dessen Längsachse nach WSW abtaucht. An zahlreichen Faltenstrukturen in unterschiedlichen Maßstäben kann direkt beobachtet werden, wie homogener sinistraler simple shear im ENE-streichenden Lagenstapel durch aufrechte, E-W streichende Falten kompensiert wird. Aufgrund dieser Beobachtungen scheint auch eine Quantifizierung des an der Schöberspitzen Antiform kompensierten Versatzes der Ahorn Scherzone durch Retrodeformation des aufgefalteten Hochstegen Marmors gerechtfertigt.

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Crystal chemistry and micro-Raman spectroscopy of Ba-rich white micas from the innermost contact aureole of the Lienz/Edenwald tonalite

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Ba-micas can occur in a variety of geological environments, but mostly they occur in contact metamorphic rocks. In the vicinities of plutons the formation of Ba-micas is strongly influenced by the presence of hydrothermal fluids and thus can be classified as a product of metasomatic processes. The ideal composition of the dioctahedral Ba-rich white mica ganterite $[Ba_{0.5}(K+Na)_{0.5}]Al_2(Si_{2.5}Al_{1.5})(OH)_2$, formerly known as oellacherite, represents a 1:1 mixture along the solid solution between muscovite/paragonite (true micas) and the Ba-brittle mica. Ba occurs in the interlayer positions with corresponding substitutions in the tetrahedral layers (MA & ROSSMAN 2006). The accommodation of larger cations in the M-sites increases the size of the interlayer position by reducing the rotation angle of the tetrahedral position which promotes the incorporation of Ba (HETHERINGTON et al. 2003). The most common substitution involving Ba in micas is Ba Al^{IV} K_{-1} Si_{-1} (HETHERINGTON et al. 2003, GRAESER et al. 2003).

The micas of this study occur in the contact aureole adjacent to the Oligocene Lienz/Edenwald tonalite in the surrounding fine-grained mica schists of the Austroalpine basement. Thermometric calculations using Ti-in-biotite thermometry yielded temperatures of 680±33 °C for the innermost part of the aureole. Electron microprobe analyses of the white micas showed that the Ba content reaches up to 13.38 wt.% BaO, even though Ba is not the dominant interlayer cation. The formula of a typical Ba-rich white mica is
$(Ba_{0.3}K_{0.41}Na_{0.22})_{\Sigma 1.00}(Al_{1.93}Mg_{0.02}Fe_{0.03}Ti_{0.02})_{\Sigma 2.00}[Si_{2.66}Al_{1.34}O_{10}](OH)_2$.

Increasing Ba concentrations are correlated with an increase in Na and a decrease in K. The octahedral position is mostly filled by Al, whereas only traces of Ti, Fe^{2+} and Mg are present. The Ba-rich micas are characterized by higher concentrations of Al[T] and lower K contents than in normal Na-K micas. The composition of the Ba-rich white micas can be described by various exchange vectors: 1.) the simple interlayer $[Na] = [K]_{-1}$ exchange and 2.) the $[Al][T] = [Si][T]_{-1}$ substitution which occurs over the complete range of Ba contents. The substitution on the tetrahedral site is balanced by a $[Ba] = [K]_{-1}$ exchange in the interlayer position. The often-cited Ba-substitution including elements on the octahedral site $[Ba][Fe, Mg] = [K]_{-1}[Al^{VI}]_{-1}$ is not well developed and only a slightly negative correlation between Ba^{2+} and Mg^{2+} and a positive correlation between Ba^{2+} and Ti^{4+} can be observed anyway. Therefore, the composition of the Ba-rich with micas in the contact aureole of the tonalite can be described with a combination of the coupled substitution namely $[Ba][Al^{IV}] = [K]_{-1}[Si]_{-1}$ and the simple $[Na] = [K]_{-1}$ exchange vector.

Complete solid solutions between muscovite and Ba-rich white micas were observed since Ba contents range from 0.07 wt.% up to 13.38 wt.% BaO. The micro-Raman spectra of the Ba-rich white micas correspond well with the standard muscovite pattern. The comparison between micas with lower (0.07- 0.26 apfu) and higher (0.29-0.37 apfu) Ba contents yielded that the peaks at 265 cm^{-1} and 396 cm^{-1} show a distinct shift as a function of the Ba content of the micas.

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Major, minor and trace element variations of apatite and tourmaline as a function of metamorphic grade in the contact aureole of the Lienz/Edenwald tonalite

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The distribution of major and trace elements in accessory minerals can provide important information on the metamorphic evolution of rocks. The aim of this investigation is to evaluate the influence of increasing temperature on the chemical composition of apatite and tourmaline using samples along a well defined profile within the contact aureole of the Oligocene Lienz/Edenwald tonalite. Minor element variations in apatites do not seem to vary systematically, but a distinct increase towards the contact was observed in Mn, Cl and ΣREE + Y. The increasing incorporation of REE + Y can be described by the coupled substitution $(REE + Y)^{3+} + Na^{+1} = Ca^{2+}_{-2}$. The major anion constituents, F and OH, show a systematic variation with respect to the metamorphic grade. On the other hand Cl does not vary consistently, although an overall increase towards the contact was observed. The elevated Cl contents in the innermost part of the aureole closest to the pluton probably results from the circulation of hydrothermal fluids associated with the intrusion process.

In contrast to apatites, tourmalines from this contact aureole are characterized by complex textural zoning, which is also reflected in strong chemical zoning. This zoning pattern displays at least two main growth events, where the inner rim shows higher Al[T], Ca and Ti contents and lower Si, Mg[Y] Al[Y] contents compared to the composition of the core and outer rim. With increasing metamorphic grade the tschermak-substitution becomes more significant (HENRY & DUTROW 1996), which results in higher amounts of Al and lower Si and Mg contents. The chemical zoning of the investigated tourmalines can thus be interpreted as a prograde growth sequence from the core (probably Variscan metamorphism) to the inner rim and growth during decreasing metamorphic grades from the inner rim to the outer rim. This chemical trend can be observed in all contact metamorphic samples throughout the contact aureole.

This study shows that accessory minerals do provide important information concerning 1.) the extent of a thermal overprint, 2.) the polymetamorphic nature (tourmaline) of rock samples as well as 3.) evidence of episodes of localized fluid/rock interactions (apatite).

Cracked pebbles - a gauge to constrain overburden

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Brittle, radially fractured pebbles from unconsolidated sediments were investigated in a gravel pit south of St. Margarethen (Burgenland, Austria). The outcrop is located in the Neogene Eisenstadt-Sopron Basin, which is a subbasin on the SE border of the Vienna Basin. The sediments, which were deposited during the Sarmartian and Pannonian (12.7-7.2 Ma), represent a succession of deltaic gravels with intercalations of shallow-marine calcareous sands. Extensional tectonics in these sediments resulted in the generation of conjugate sets of predominately WNW- and subordinate ESE-dipping normal faults (shear deformation bands). These faults were primarily localized in meter-thick gravel layers and, with increasing displacement, eventually crosscut other lithologies.

The gravel layers contain a significant number of cracked pebbles. Detailed structural mapping of the distribution of cracked pebbles revealed their preferential occurrence in the vicinity of the normal faults and, in these, within zones of roughly uniform-sized pebbles. The findings indicated a strong relation to the mechanics of faulting within the sediment. To find the controlling factors for the localization of pebble fracturing, the grain-size distribution and shape and the number of point contacts of the pebbles were statistically measured. The results were then used as input parameters for numerical modelling.

The Discrete Element Method was applied to simulate the effect of overburden on a certain volume of particles (i.e. the pebbles). The magnitude and the distribution of contact forces between the particles were observed and compared with the fracture resistance of natural pebbles, determined by point load testing in the laboratory.

Results from numerical modelling indicate that a maximum estimated overburden of a few tens of meters would not have been able to generate contact forces high enough to crack the significant number of pebbles that have been observed in some parts of the outcrop. We therefore conclude that cracking was related to faulting by force