orthogneisses. The carbonatic rocks are characterised by two mineral assemblages who represent two different metamorphic events. (1) forsterite + (Cr-) spinel + diopside + geikielite + calcite + dolomite ± phlogopite ± wollastonite ± Ti-clinohumite which represents a contact metamorphic assemblage and (2) garnet + omphacite + rutile + calcite + dolomite ± phlogopite ± clinozoisite which represents an eclogite-facies assemblage. The complex polymetamorphic history of these rocks is also reflected in the occurrence of rare accessory minerals. In addition to the common Ti-phases such as titanite and rutile also geikielite and rare Zr-bearing phases such as baddeleyite and zirconolite occur. In one sample (B4) scheelite was found at the rims of titanite. Titanites in the eclogite-facies assemblage often show a distinctive chemical zoning with cores showing high REE (La, Ce, Nd) and HFSE (Zr, Ta) contents while the rims are depleted in REE and show highly enriched Al and F contents. The cores thought to represent a pre-Variscan contact metamorphic event which is consistent with the higher REE and HFSE contents due to the mobility of these elements during metasomatic processes. The rims have grown as a result of the eclogite-facies overprint during the early Variscan metamorphic event. In addition, rutile occurs in both assemblages (1) and (2). In the contact metamorphic samples (1) rutile is present as a narrow rim around geikielite forming due to the model- reaction geikielite + CO_2 <--> rutile + magnesite which takes place with increasing pressures. This indicates that carbonates which mostly contain mineral assemblage (1) have also undergone a *P*-accentuated metamorphic stage. For both titanite and rutile, Zr-geothermometry was applied according to Tomkins et al. (2007), and Hayden et al. (2008). Rutile inclusions in eclogitic garnets yielded temperatures between 676-757 °C at 2 GPa, while matrix rutile shows temperatures ranging from 708 to 749 °C. The Zr-in-titanite thermometer yielded 600-720 °C for the cores and 680-800 °C for the rims. The temperatures obtained by rutile and titanite are in good agreement with results calculated by THERMOCALC v. 3.21 and the data set of Holland & Powell (1998). Zirconolite and baddeleyite occur only in a few samples of the contact metamorphic carbonates (PT9, PT166, PT179). Purtscheller & Tessadri (1985) observed in one sample baddeleyite being replaced by zirconolite according to model-reaction baddeleyite + 2geikielite + 3calcite + CO_2 <--> zirconolite + 2dolomite. This indicates according to Tropper et al. (2007) growth during an increase in XCO_2. Samples which contain the eclogitic-facies mineral assemblage show zircon as the only Zr phase. Therefore SiO_2 saturation is required to form zircon. This leads to the assumption that XCO_2 and $aSiO_2$ increased from the pre-Variscan contact metamorphic event to the Variscan high-pressure stage due to an influx of a SiO_2-rich fluid. Electron-microprobe dating of zirconolite yields two cluster of ages (1): ages between 402-491 Ma which represent the pre-Variscan contact metamorphic event and (2): slightly younger ages between 366-399 Ma which can be attributed to the Variscan high-pressure stage.

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The metamorphic evolution of metacarbonates from the central Ötztal Complex (Pollestal, North-Tyrol, Austria): mineralogical evidence for episodes of contact metamorphism and high-*P* metamorphism

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In the central part of the Ötztal Complex (Pollestal) dolomitic metacarbonates occur as small lenses intercalated between metabasic and granitic rocks. Based on petrography and textural evidence, two different groups of carbonates can be distinguished which probably represent two separate metamorphic events: (1) the assemblage forsterite + (Cr-)spinel + diopside + geikielite + calcite + dolomite ± phlogopite ± wollastonite ± Ti-clinohumite is interpreted to represent a pre-Variscan contact metamorphic assemblage and (2) the assemblage garnet + omphacite + rutile + calcite + dolomite ± phlogopite ± clinozoisite represents the Variscan eclogite-facies assemblage. Additionally rare accessory minerals such as baddeleyite and zirconolite occur in mineral assemblage (1), similar to rocks from the Bergell-, Adamello- and Stubenberg-contact aureoles. Wollastonite occurs in small calcsilicate lenses and is surrounded by a rim of diopside. According to the T-XCO_2 phase relations in the contact metamorphic marbles wollastonite formed by reducing XCO_2 or increasing temperatures. The presence of olivine at temperatures of 550-600 °C (Tropper et al. 2003) requires the existence of a very H_2O-rich fluid which is in agreement with the formation of wollastonite by reducing XCO_2. T-XCO_2 calculations with the program THERMOCALC v. 3.21 and the data set of Holland & Powell (1998) using the reaction 3dolomite + diopside <--> 2forsterite + 4calcite + $2CO_2$ yielded low $XCO_2 < 0.15$. Zoned chromite/chrome-spinel occurs with maximum Cr_2O_3 contents of 36.57 wt.% (core) and shows orientated exsolution lamellae of ilmenite along the (111) crystallographic direction in the cores. The zoning then changes to Mg-Al-spinel (65-68 wt.% Al_2O_3, 24-26 wt.% MgO) at the rim which is according to Mogessie et al. (1988) a result of increasing metamorphism. Olivine-spinel geothermometry calculated with THERMOCALC v. 3.21

yielded temperatures ranging from 537 °C to 711 °C at pressures of 5-7 kbar for the pre-Variscan contact metamorphism. Calcite-dolomite thermometer yielded slightly lower temperatures between 448-599 °C.
Carbonate samples containing metabasic boudins are characterised by an eclogitic mineral assemblage described by omphacite (Jd_{30-50}) and complex zoned garnets with several growth stages in the rims. Within these boudins chemically two generations of garnets showing different contents of almandine and grossular in the core can be distinguished. Type 1 consists of a core enriched in Fe (Alm_{49-51}) while Ca increases from the core (Gro_{30}) to the rim and reaches the highest values in the outermost zone (Gro_{66-67}). Type 2 shows the highest amount of Fe (Alm_{42-50}) and the lowest Ca (Gro_{33-42}) in the rim next to the core. The Jd-content of omphacite inclusions reveals that the cores of type 1 and the innermost rims of type 2 reflect the maximum of pressure. After reaching the *P* peak *T* increased and caused a rise in Mg as explained by the reaction grossular + 6rutile + 3diopside <--> 6titanite + pyrope. This also agrees with the absence of rutile in garnet-rims containing the highest pyrope component. Garnets also show as a consequence of subsequent decompression either a symplectitic intergrowth of diopside (Jd_{7-20}) and plagioclase (An_{13-23}), or pargasitic amphiboles replacing garnet, which represents the late-stage transition from eclogite- to amphibolite-facies.

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Monometamorphic Austroalpine basement units and their significance for Eo-Alpine tectonics: A comparative study from Schneeberg and Radenthein Complexes

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The Schneeberg and Radenthein Complexes comprise metasedimentary units that experienced solely Cretaceous metamorphism. These units are sandwiched between polymetamorphosed basement units. The Schneeberg Complex is overlain by the Alpine weakly metamorphosed Ötztal Nappe and underlain by the Alpine high-grade metamorphosed Texel Complex. The Radenthein Complex is overlain by the Alpine weakly metamorphosed Bundschuh Nappe and underlain by the Alpine high-grade metamorphosed Millstatt Complex. Both, the Schneeberg-Radenthein Complexes together with the Texel-Millstatt Complexes, are part of the Koralpe-Wölz high pressure nappe system (SCHMID et al. 2004) and hence define a probable intracontinental suture zone within the Austroalpine nappe stack. Before Miocene unroofing of the Tauern Window the Schneeberg and Radenthein Complexes were attached and hence should record a comparable tectonic history. Problems, however, arise from different overall orientations of these units now located west and east of the Tauern Window, with a general North-dip in the West and a South-dip in the East. This situation was attributed to retro-wedge and pro-wedge tectonics, respectively. In addition, the existence of Alpine unmetamorphosed (or weakly metamorphosed) sediments within the Alpine nappe pile raises questions upon reliability of the traditional basement-cover systematics within the Eastern Alps that provide the basis for definition of major tectonic units.
We consider that Miocene tectonics, i.e. different amount of shortening released by the Adriatic indenter, accounts for different orientation of units to the west and east of the Tauern window. Thus before indentation both, the Schneeberg and Radenthein Complexes, were south dipping units with a comparable tectonic history between ca. 90 and 60 Ma. Deformation stage D1 is characterized by WNW directed shearing at high temperature conditions (550-600 °C) and related with initial exhumation of the high pressure wedge. Deformation stage D2 is largely coaxial and evolved during high- to medium temperature conditions (ca. 450 to >550 °C) with local annealing textures. This stage is related to advanced exhumation of the previous wedge and associated with large scale folding, especially known from the Schneeberg Complex but also proposed for the Radenthein Complex. Deformation stage D3 evolved at lower temperatures (ca. 400-500 °C), is related to east - southeast extension and considered responsible for the main exhumation of metamorphosed basement units, including Ötztal and Bundschuh nappes. Deformation stage D4 is of Oligocene to Miocene age and responsible for tilting of individual blocks. North-South shortening caused the well known fold interference patterns occurring in both complexes. Concerning Alpine geodynamics we suggest that (1) existence of an Eo-Alpine retro-wedge is not mandatory if Miocene tilting along the northern Apulian plate is considered effective. (2) We consider the Schneeberg and Radenthein Complexes as metamorphosed equivalents of Paleozoic sediments deposited on the Texel and Millstatt Complexes that define central portions of the later intracontinental subduction zone. The Ötztal and Bundschuh Complexes are considered as external units in the foreland of the later subduction zone.

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