Thermal and structural evolution of the South Tauern margin (Lappach, Südtirol): Evidence from stable isotope and structural studies

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The South Tauern margin is characterized by changing structures in west-east direction. Where the Austroalpine corridor between South Tauern window and Periadriatic Lineament is narrow (western portion, ca. 2 km) foliation dip to the north. In eastern portions, where this corridor widens towards ca. 20 km, the foliation plane dips towards south. There is an increasing amount of shortening induced by indentation of the Adriatic plate between western and eastern domains and the structural variation likely coincides with the external boundary condition. Within the study area the dominant foliation is vertical with pronounced subhorizontal stretching. In addition the structural assembly in the Lappach area is characterized by an additional structural element on map scale, the Lappach structure, that might by interpreted by large scale folding and/or shearing. We present structural and thermal data from this domain in order to constrain relation between thermal and structural activities and to explain large scale west-east trends in the structural evolution.

Dominant structures in the Lappach area include vertically foliated and horizontally stretched rocks associated with sinistral sense of shear. However, fabric and texture asymmetries are poorly developed. Hence, we interpret these features as result of pure shear dominated transpression and extrusion during Oligocene indentation tectonics. This deformation is overprinted by south-vergent folds that include a weakly developed axial plane cleavage, especially within inverted fold limbs.

Stable isotope data have been performed to constrain thermal history along a cross section from the South Tauern Window margin to the northern Zentralgneis. We used information from isotopic equilibrium/disequilibrium between calcite, muscovite and quartz separated rocks of very similar bulk composition (calcschists). Isotope ratios and calculated temperatures show equilibrium conditions between all phases in northernmost portions (close to Zentralgneis) and increasing disequilibrium towards the south. Generally, temperatures increase from the southern Glockner Nappe to the northern Zentralgneiss from ca. 400°C to 520°C. This temperature increase fits well with estimates of thermal conditions derived from quartz and calcite textures as well as from petrology. However, within single the southernmost Glockner Nappe, temperatures decrease from south to north. This area is characterized by intense folding (Lappach Fold) and faulting, therefore, thermal disturbances likely coincide with tectonic complications.

We argue that in early stages of fabric evolution in the Tauern Window the thermal overprint post-dated tectonic structures. By contrast, during the late tectonic evolution, the thermal paleo-isograde, “frozen” in isotope ratios of calcite, muscovite and quartz, have been refolded. We relate this late-stage structures with back-folding and back-thrusting of Tauern Window units onto the southern Austroalpine domain. Back-folding was strong along western sectors and weak along eastern portions of the South Tauern margin. Modeling of isotope ratios suggests that cooling and exhumation rates were high within the central Tauern Window and decreased towards the margin.

Re-Os and U-Pb age constraints for tungsten and molybdenum deposits in the Tauern Window, Austria

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The pre-Alpine units in the Tauern Window host economic tungsten and subeconomic molybdenum deposits at Felbertal and Alpeiner Scharte, respectively.

The Felbertal scheelite deposit in the central Tauern Window occurs in a Cambrian sequence (calc-alkaline metabasites, orthogneisses etc.) formed at an active margin, which was intruded by Variscan granitoids of mainly Early Carboniferous age. Molybdenite from the quartz cupola developed around one of these geochemically highly anomalous orthogneisses (K1-K3 gneiss 336 ± 19 Ma, Hoell and Eichhorn, 2000) has a Re-Os age of 345.3 ± 1.3 Ma. Molybdenite aligned parallel to the dominant foliation in a banded scheelite ore (K2 ore body) yielded Re-Os ages of 338.6 ± 1.3 and 340.2 ±

1.3 Ma, respectively. Interestingly molybdenite in scheelite-quartz stockwork veins underlying the laminated high-grade quartzitic scheelite ore body in the abandoned Eastern Ore Field yielded 343.0 ± 1.4 Ma, which is within the 2 sigma uncertainty of the ages from the Western Ore Field; previously this mineralisation has been interpreted as Cambrian in age (Hoell and Eichhorn, 2000). A Re-Os isochron age of 340.1 ± 8.4 Ma, calculated from these four data, is regarded as the best estimate for molybdenite formation at Felbertal. One molybdenite sample from a strongly deformed vein in a retrogressed metabasite found at the Eastern Ore Field gave a mean age of 416 ± 19 Ma.

The Alpeiner Scharte Mo mineralisation in the western Tauern Window is hosted by Variscan metagranitoids, which intruded into a basement of metasediments and older intrusives. Molybdenum mineralisation is hosted in E-W trending quartz veins and rarely in aplitic dykes and evidence the same Alpine deformation (D1-D4) and metamorphic history (550-600°C, 7-8 kbar) as the host rocks. Extremely low Re concentrations prevented successful Re-Os dating of molybdenite but may indicate a crustal source of metals. Magmatic zircon grains from two orthogneisses were dated at the NORDSIM laboratory in Stockholm. U-Pb ion probe dating of a coarse-grained leucocratic orthogneiss ("Typ Fußstein") gave an emplacement age of 304.4 ± 7.1 Ma (Tera Wasserburg plot, 2 sigma uncertainty); a second sample from the biotite-rich orthogneiss variety ("Typ Alpeinerscharte"), which is crosscut by Mo veins yielded 308 ± 4.6 Ma. Hence Mo veins at Alpeiner Scharte must be younger than ~303 Ma but predate Alpine events.

Two independent Variscan mineralisation stages, each genetically related to granite-related magmatic-hydrothermal systems are distinguished in the Tauern area. A main stage of W(-Mo) mineralisation of early Carboniferous age is recorded for Felbertal. In contrast Mo-veins at Alpeiner Scharte are significantly younger and related to post-orogenic (?) late Carboniferous magmatic activity.

A pre-Variscan mineralisation stage is so far only indicated by the ~420 Ma molybdenite age from Felbertal. We may speculate that it corresponds to Caledonian high-P metamorphism documented from elsewhere in the Tauern Window. A Cambrian mineralisation stage, postulated for Felbertal by Hoell and Eichhorn (2000) has not yet been confirmed.

Hoell, R. & Eichhorn, R., 2000, Tungsten mineralization and metamorphic remobilization in the Felbertal scheelite deposit, Central Alps, Austria [Monograph] Metamorphosed and metamorphogenic ore deposits: Rev. Econ. Geol., 233-264.

Zur Geochemie jurassischer Manganschiefer der Nördlichen Kalkalpen - hydrogene versus hydrothermale Entstehung stratiformer Manganmineralisationen der Ostalpen

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Die Bildungsbedingungen pelagischer Manganschiefer aus dem Jura der Ostalpen können durch die Untersuchung der Seltenen Erd Elemente, Haupt- und Spurenelemente besser verstanden werden. In diesem Beitrag werden Daten aus 24 Proben der Nördlichen Kalkalpen präsentiert. Die Verteilung der Haupt- und Spurenelemente wird vom terrigenen Detritus bestimmt. Die Verteilung der Seltenen Erd Elemente und die Beziehung zwischen organischem Kohlenstoff und (pyritisch gebundenem) Schwefel kann dagegen zur genetischen Interpretation der Mangananreicherung herangezogen werden. Es zeigt sich, dass die Analysendaten dieser Studie durch das Modell der hydrogenen Manganabscheidung durch stark variierende Redox-Verhältnisse am Meeresboden erklärt werden können.