tutions. The octahedral vacancy of chlorites together with the celadonite content of white K-micas prove elevated pressure.

Illite and chlorite crystallinity indices rather homogeneous, medium- to high-T anchizonal metamorphic conditions, with slight increase of grade (temperature) from Meliata through Držkovce to Hačava. This trend is supported also by the chlorite-Al^{IV} geothermometry that has provided maximal temperature values of 300, 340 and 350 °C for the Meliata, Držkovce and Hačava slates, respectively. The retrogression of the greenschist facies phyllites from Rožňavské Bystré occured also in anchizonal circumstances.

Qualitative white K-mica *b* geobarometry shows medium, transitional medium-high pressure type metamorphism at the localities of Meliata and Roznavske Bystre. White K-mica averages from Drzkovce and Hacava may suggest transitional low--medium pressure, although the disturbing effect of paragonite content can not be ruled out. As a consequence, moderate variations in P/T ratio seem to be probable in the very low-grade sequences.These results suggest a diverse range of metamorphic conditions reflecting complex structural mixing of metamorphic components at shallower levels.

Differences in burial pressure estimates and inferred geothermal gradients occur between the various localities of the slate-chert-basalt-turbidite sequence. Metamorphism of these rocks occurred at shallow levels closer to the toe of the accretionary complex. Although temporal relations are not well constrained, the evolution of these terranes is consistent with formation within a single convergent-margin system. The K-Ar ages obtained on the white K-mica-rich <2μm grain-size fraction samples scatter between 178 and 115 Ma. Considering the closure temperature of these fine-grained micas and the eventual effect of inherited, detrital micas, the age interval of very low-grade metamorphism of the Meliata unit may be between c. 150 and 115 Ma, i.e., between the Middle Jurassic blueschist facies event of the Meliata unit and the Upper Cretaceous low to low--intermediate pressure type very low-grade metamorphism of the Bükkium. The deformed matrix material of the Meliata mélange formed at lower temperatures and lower pressures, on the order of 250–350°C and 3–6 kbar. The mélange contains a diverse assemblage of tectonic blocks that formed under a range of P-T conditions, including those of the blueschist, pumpellyite-actinolite and greenschist facies.

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Fluid Compositions in High-grade Rocks: An Example from the Lapis Lazuli Deposits at Sare Sang, Afghanistan

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The world known lapis-lazuli deposite at Sare Sang in Hindukosh occurs within high-grade metamorphic rocks (Sare Sange Series) which are part of Precambrian South Badakhshan block (NE Afghanistan). The primary volcano-sedimentary sequences of the Sare Sange Series were intercalated by carbonates and probably by evaporites. P-T conditions estimates based on mineral assemblages in whiteschists (Schreyer and Abraham 1976) and in metapelites and metabasites (Faryad 1999) reached triple point of amphibolite-eclogite – granulite facies (750 °C, 14 kbar). The most common minerals in calc-silicates are clinopyroxene, calcite, quartz and garnet or phlogopite. As accessory phases they may contain olivine, nepheline, titanite, apatite, sodalite and hauyne. Some metabasites with scapolite contain clinopyroxene, orthopyroxene, garnet, biotite and calcic amphibole.

Clinopyroxene from calc-silicate rocks is mostly diopside with a maximum jadeite content of 29 mol% and rarely also hedenbergite. Garnet from calc-silicates is rich in Ca (Grs_{45-95}), but metabasites contain pyrope-rich garnet (Py_{36-43}). Textural and phase relations indicate that scapolite and some halogen-bearing phases (apatite, phlogopite, amphibole and titanite) were formed during prograde metamorphism of carbonate-evaporite sequences. The scapolite exhibits a wide range of composition (from $Eq_{An} = 0.07$, $X_{Cl} = 0.99$ to $Eq_{An} = 0.61$, $X_{Cl} = 0.07$), depending on the rock type.

Mineral compositions and reactions imply the presence of fluid phases with high concentrations of CO_2 and salts during metamorphism of the rocks. The $X_{CO2} = 0.03 – 0.15$ contents at peak P-T conditions were estimated using scapolite-bearing reactions. Halogens and S are involved in the following minerals: F (apatite, biotite, amphibole, titanite, clinohumite), Cl (scapolite, sodalite, biotite, amphibole, apatite) and S (haüyne, lazurite, scapolite, pyrite and pyrrhotite). Blaise and Cesbron (1966) reported the presence of gypsum and galena, associated with calcite and sodalite. With the exception of accessory pyrrhotite, pentlandite and some scapolites, the S-bearing minerals originated during retrogression and metasomatism. Partitioning of F and Cl between coexisting phases was calculated for apatite-biotite ($F_{Cl}^{Phl} + H^{Ap} = Phl + F_{Cl}^{Ap}$ and $K_{D,F(Cl)}^{Ap/Phl}$) and amphibole--biotite ($\log(X_F/X_{OH}$, $\log(X_{Cl}/X_{OH}))$. Fluorapatite is present in calc-silicates, but metabasites contain chlorapatite. Cl is preferentially partitioned into amphibole relative to biotite. All these rocks have suffered varied degrees of retrogression, which resulted in removal of halogen, CO_2 and S, and were infiltrated by dilute fluids. Fluid-bearing minerals formed during retrogression and metasomatism were fluorapatite, sodalite, amphibole, clinohumite, hauyne, pyrite, and lazurite, which either form veins or replace earlier formed phases.

Textural relations indicated the presence of several varieties of scapolite in the Sare Sang rocks. Compositional variation in this high-grade scapolite from various samples is related to certain rock type. This can be explained by relatively large marialite content in scapolite from garnet-free calc-silicates, where the coexisting phases such as apatite, amphibole and biotite are rich in Cl. The calculated equilibrium reactions of the Sare Sang rocks indicate that scapolite coexists with pyroxene and/or garnet, hence belongs to the earlier formed phases in the rocks, and it was partly affected by later metamorphic events. The presence of NaCl-scapolite in metamorphosed rocks generally implies an evaporitic source with NaCl provided from salt-rich layers, either locally or distally. Sedimentary origin of NaCl in the Sare Sang rocks is assumed by the stratigraphic control of the occurrence of carbonate and Na- or Al-Mg-rich minerals that were distributed parallel to bedding. The scapolite crystallized during regional metamorphism in rock layers that originally contained halite, calcite and dolomite. Additionally, the occurrence of phlogopite or Mg- and Al-rich biotite with only minor K-feldspar may indicate metamorphism of evaporitic argillites. There is no significant compositional variation between textural varieties of scapolite in one sample. This suggests mostly a closed system for recrystallization or formation of scapolite during later metamorphic history.

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Metamorphism Along a South-North Cross-section in the Middle Austroalpine Units East of Tauern Windows (Easter Alps, Austria)

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The Austroalpine tectonic units display a complex internal structure that formed mostly during Cretaceous tectonic processes. Basement rocks with Pre-Alpine amphibolite to eclogite facies conditions were affected by Alpine penetrative deformation and greenschist to amphibolite/eclogite facies metamorphism (Neubauer et al., 1999). The Middle Austroalpine units east of the Tauern Windows indicate a southwards grading Alpine metamorphism. To distinguish Alpine and Pre-Alpine assemblages and to constraint variation in P-T conditions existing during Alpine metamorphism, metapelites and metabasites along a south- northwards profile, from northern sector of the Saualpe and Koralpe Complex, trough Wölzer Tauern (Micaschist-Marble Complex) to the Hochgrößen massif in the Rottamann Tauern (Speik Complex and Permian Rannach Formation) were investigated.

The most common minerals in metapelites from the Seetaler Alps are garnet, white mica, quartz, kyanite and rare staurolite and kyanite. Garnet contains inclusions of quartz, micas, rutile, ilmenite, plagioclase, staurolite and kyanite. The metabasites consist of garnet, amphibole, plagioclase, quartz and symplectites of pyroxene + plagioclase + amphibole. Minor and accessory phases are relict omphacite, epidote-zoisite, rutile, ilmenite, titanite and calcite. Some samples may additionally contain white mica and biotite. Similar mineral assemblages as that in the Seetaler Alps are present in metapelites from the Wölzer Tauern. However, garnet is formed by two zones, which originated during different metamorphic events. Metabasites from the Wölzer Tauern consist of garnet, plagioclase and amphibole, and contain no symplectites or omphacite. The Speik Complex rocks at Hochgrößen massif are represented by serpentinites and retrograde eclogites. Fresh eclogites are rare and contain omphacite with a maximum of 39 mol% jadeite content, garnet and amphibole. Retrograde eclogites consist of amphibole and symplectites of Na-poor clinopyroxene (5–8 mol% Jd) + albite ± amphibole of edenite composition. The Permian Rannach Formation rocks, which are tectonically imbricated in serpentinites, contain quartz, white mica, chlorite and chloritoid.

An early Variscan high-pressure metamorphism of the Speik Complex rocks is assumed by $^{40}Ar/^{39}Ar$ radiometric dating (397.3 ± 7.8 Ma) from edenitic amphibole in eclogite at Hochgrößen massif (Faryad et al. 2001). Garnet-pyroxene thermometry yielded an average temperature of 700 °C for eclogite facies metamorphism. A minimum pressure of 15 kbar is indicated by the maximum jadeite content in omphacite. Peak P-T conditions of 700 °C/18 kbar for eclogite facies metamorphism were