has orange luminescence without growth zones. Younger population (light orange CL) crosscuts the older one (dark orange CL) in form of tiny veinlets.

REE in fluorite

Total content of REE in analyzed fluorites varies between 46 and 273 ppm. REE chondrite-normalized patterns differ at single localities (flat curve without any anomaly and LREE enrichment at Tetčice, a well-balanced curve and a strong positive Eu anomaly at Rakšice). However, both total content and distribution of REE correspond well with those of surrounding rocks. The level of REE fractionation (in the Tb/Ca vs. Tb/La plot) indicate hydrothermal origin of all studied fluorites.

Fluid inclusions

Primary and primary-secondary fluid inclusions have been studied in fluorites. Inclusions are always two-phase (type L+V), with 2-5 vol.% of vapour phase. Homogenization temperatures range between 83 and 165 °C. Inclusions completely freeze at temperatures from -29 to -47 °C. Eutectic temperatures around -20 °C indicate presence of NaCl-H_2O fluid. Last ice crystal melts between 0.0 and -2.6 °C, so the given range for Tm values corresponds to the very low salinity of the trapped solution (between 0 and 4.3 wt.% NaCl eq.). Distribution of the measured data in the Th/salinity plot indicate mixing of more saline and warmer fluid with less saline and cooler one. In fluid inclusion is further probably present small amount of CO_2. Fluid inclusions in associated minerals exhibit, actually, the same fluid characteristics as those in fluorites.

Stable isotopes

Isotopic composition of C and O was determined in calcites from Tetčice. The $\delta^{13}C$ and $\delta^{18}O$ values vary between −6.7/−9.9 ‰ and −7.5/−15.0 ‰ PDB, respectively. Calculated carbon isotopic composition of the parent fluid is around −11 ‰ PDB. Source of carbon was probably in the host rocks, but some admixture of organic carbon cannot be excluded. Calculated $\delta^{18}O$ values of the fluid ranging between 0 and −7.5 ‰ SMOW are typical of meteoric water.

Conclusion

The investigated mineral associations precipitated from low-saline fluids at temperatures of 80–150 °C. These fluids were probably shallow-circulating meteoric waters. Components of mineralizing fluids have been extracted from the host rocks as is documented by REE in fluorites or by carbon isotopes in calcites. The studied fluorite mineralization from the Brno massif could be compared with the Tertiary fluorite mineralization described from the North Bohemia region (Teplice, Jílové u Děčína, Žák et al. 1990).

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Accretionary Type Metamorphism in the Meliata Unit (Western Carpathians, Slovakia)

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The blueschist belt of the Meliata unit, formed during the mid--Jurassic (165–170 Ma) high-pressure metamorphism of continental margin and oceanic sequences, occurs south of the Gemericum in east Slovakia. Besides isolated slices overthrusting the basement units to the north, the high-P/T metamorphic rocks are preserved within very low-grade sedimentary sequences, consisting of slates, metasandstones, -siltstones and locally, evaporites. The metasedimentary mélange has been traditionally assumed as an unmetamorphosed series (Meliata series s.s.). The evaporite--bearing formations, which were locally found both in the Slovak and Hungarian territories, played an important role in the structural deformation of the Meliata accretionary wedge.

Recent studies on the Meliata unit have been mostly related to petrology of ophiolites and blueschists (Faryad 1995; Mazolli and Vozarova 1997; Ivan and Kronome 1995 and references therein and Horváth 2000). By contrast, little attention has been devoted to their mélange matrix (Árkai and Kovács 1986). The present work provides some new results on the very low-grade rocks of the Meliata unit. Sedimentary rocks, some of them mixed also with very fine-grained, altered basic volcanoclastic material, were collected from four localities (Meliata, Držkovce, Rožňavské Bystré and Hačava).

Si contents of white K-micas vary between 3.1 and 3.6, the FM values between 0.05 and 0.55, the total R^{VI} contents between 2 and 2.2 a.p.f.u. The total interlayer charge is predominantly 0.8–0.9 a.p.f.u., the Na/(Na+K) ratio scatters between 0 and 0.1, both parameters being characteristic of very low-grade micas. From the Hačava locality dark marly slate samples contain white micas corresponding to paragonite and phengite with Si content between 3.30–3.35 a.p.f.u. Paragonite was found as core in relatively coarse-grained phengite crystals. Some volcanic rocks, which are in tectonic position with marble, have albite, chlorite and early blueschist facies phyllites, which underwent strong retrogression and mylonitization. They contain relics of chloritoid and pseudomorphs after glaucophane. High-Si phengite is rimmed by medium to low-Si muscovite. In chlorites the di-trioctahedral (sudoitic) substitution plays a subordinate but significant role, in addition to the $FeMg_{-1}$ and Tschermak's substitutions. 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 prefe-