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Grt Sm-Nd and mineral chemical data of meta-pegmatites and their metapelitic host rock: relating Permo-Triassic magmatic events to the polymetamorphic evolution of Austroalpine basement units (Eastern Alps)

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Permo-Triassic pegmatite emplacement has been reported from several Austroalpine units of the Eastern Alps (Thöni & Miller, 2000; Schuster et al., 2001). Constraints on the age and the duration of the magmatic event, the extent of related metamorphic processes, as well as the influence of the subsequent Cretaceous metamorphic imprint on radiogenic isotope systems are subject of the current study. New Grt Sm-Nd and mineral chemical data were obtained from the Saualpe-Koralpe basement (SK) in the E and from the Matsch Unit (Ötztal-Campo basement) (MC) W of the Tauern Window. Correlation of the metamorphic processes in the pegmatite host rock is complicated by the polymetamorphic evolution. In the SK, a Cretaceous eclogite facies metamorphic overprint is well known (Thöni & Jagoutz, 1993), whereas in the MC a Variscan (Lower Carboniferous) amphibolite facies metamorphic imprint predated pegmatite-emplacement, and the Cretaceous overprint reached greenschist to lowest amphibolite facies metamorphic conditions only.

Saualpe-Koralpe basement (SK)

Coarse-grained garnet- and aluminosilicate-bearing pegmatites were emplaced within Al-rich metapelites (“Paramorphosenschiefer”) that now contain kyanite-aggregates pseudomorphing andalusite and staurolite. Kyanite-paramorphs mimetic after an-

dalusite are also present within the pegmatites. Centimeter to decimeter-sized andalusite crystals were intergrown with coarse-grained idiomorphic garnet, tourmaline, K-feldspar, albite, muscovite and quartz, representing the magmatic assemblage along with accessory apatite, zircon, monazite and sphalerite.

Euhedral pegmatite-garnets with grain sizes of 10-20 mm are almandine-spessartine rich, with variable but generally minor pyrope and grossular contents. The regular zonation shown by element profiles along radial traverses with decreasing sps, increasing alm and py contents from the core to the rim are probably due to Rayleigh fractionation, suggesting a single-phase crystallization (values in mol% of sample WBK1: alm_{64-73}, sps_{20-30}, py_{3-7}, grs_{1-2}; sample HS00704: alm_{58-64}, sps_{30-40}, py_{2-3}, grs_{1-4}). At some Grt grain boundaries, aggregates of 10-50 micrometer sized Grt grains represent fragmented domains due to Cretaceous mylonitic deformation. Within these aggregates, as well as at the immediate contact (10-20 micron) with albite (inclusions and matrix-grains) the grs-content in Grt increases to about 7 mol% at constant sps-content. Here, almandine and pyrope-contents behave inversely relative to grossular. The magmatic major element composition clearly indicates that Grt crystallized during pegmatite-emplacement. During the subsequent high-pressure overprint, only a minor diffusive Ca-exchange between Grt and albite occurred, with neither garnet-decomposition, nor garnet-growth.

Sm-Nd isochron regression for sample WBK1 using 3 Grt-fractions (2 single crystals and 1 pure Grt fraction from the bulk crushate), the WR data point and a fraction representing mainly inclusions within Grt, yielded an age result of 250.8 $\pm$ 8.1 Ma (MSWD 7.7; ε(t)Nd = -8.6). Single Grt-WR regressions range between 247.3 $\pm$ 2.5 Ma and 253.9 $\pm$ 2.5 Ma. All Grt fractions of sample WBK1 have extremely high $^{147}Sm/^{144}Nd$ ratios of between 8 and 9.5 (chemical Sm/Nd ratio up to 15.7) among the highest Sm/Nd ratios ever reported. Pegmatite-sample WBK2, from a locality some 100 meters away, gave an identical Grt-WR age of 247.1 $\pm$ 2.5 Ma (εNd = -7.2). Our results suggest that (i) minor diffusional processes (although observed in the major element composition) did not influence the Sm-Nd budget of the hand-picked Grt fraction and that (ii) Grt and its inclusions did isotopically equilibrate during magmatic crystallization.

Since LP metamorphism in the pegmatite host rocks seems to be related to crustal partial melting processes (Habler & Thöni, 2001), the age data of pegmatite garnet constrain the timing of the most prominent stage of pre-Cretaceous metamorphism in the Saualpe-Koralpe basement which occurred close to the Permian / Triassic boundary.

Matsch Unit, Campo-Ötztal basement (MC)

Pegmatites from the Matsch Unit, which form intercalations within biotite-sillimanite-

schists and andalusite bearing staurolite-garnet-micaschists, often cut the dominant foliation of the host rock discordantly. Within major parts of the Matsch unit, syn- or post-magmatic deformation of the pegmatites is significantly weaker than the finite deformation of the host rocks. In the metapelites, kyanite, garnet and plagioclase represent the earliest relic phases of a supposedly Variscan amphibolite facies metamorphism. These minerals were then partly overgrown by coarse-grained staurolite, which in turn was replaced by andalusite. Andalusite not only crystallized within the metapelitic matrix, but also within quartz-andalusite veins. Subsequently Ky, And and St were partly replaced by sillimanite, a process that in some places was accompanied by deformation (e.g. related with the formation of micro-scale shear-zones within andalusite).

Pegmatite generation should temporally correlate either with andalusite-growth and quartz-vein formation, or with subsequent sillimanite crystallization. In the Ötztal basement north of the Matsch Unit, similar aluminosilicate-bearing quartz veins as well as minor sillimanite growth have been attributed to late stage Variscan (Lower Carboniferous) metamorphism (Tropper & Hoinkes, 1996), as cooling below 300˚C occurred there at about 310-270 Ma (Thöni, 1999, and references therein).

The first Sm-Nd analyses of a Grt-WR pair of a Matsch unit pegmatite (sample 03T41 containing the magmatic assemblage albite, quartz, white mica, garnet, beryl and accessory apatite, Zn-spinel, sphalerite and zircon) yielded 255 $\pm$ 5 Ma (ε(t)Nd = -10.8). The Grt has an almandine-spessartine composition and shows a homogeneous major element distribution (mol%: alm_{71-78}, sps_{21-28}, py_1), which is identical within both 1-2 mm sized grains and 10-50 micrometer sized garnet fragments. The possible presence of a second garnet growth stage, as well as any influence of post-magmatic (Cretaceous) thermal processes on the primary major element composition of garnet may therefore be excluded for sample 03T41. However, the precise temporal correlation of low pressure crystallization in the metapelitic host rock and the pegmatite itself is uncertain, since both Late Variscan and Permian low pressure assemblages should be taken into account.

Conclusions

Available geochronological data, including those from the present study, constrain the age of pegmatite formation in different Austroalpine units to the Upper Permian-Lower Triassic. The Sm-Nd system in garnet was not significantly influenced by the Cretaceous metamorphic overprint, even at eclogite facies PT conditions and intense deformation. Pegmatite formation is related to low pressure metamorphism in the host rocks and the data therefore constrain the age of this pre-Cretaceous metamorphism, at least for the SK basement. Schuster et al. (2001) ascribed the Permo-Triassic event of LP metamorphism and magmatism to lithospheric extensional processes. Although

the SK and the MC differ in their pre- and post- Permo-Triassic tectonometamorphic evolution, both were affected by pegmatite-emplacement within a similar time range and therefore could have formed a coherent unit at that stage. However, the clear discrimination of Late Variscan and Permian metamorphic processes in the Matsch unit requires additional geochronological and petrological data from the pegmatite host rocks.

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