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# A RECORD OF DEVONIAN HIGH-GRADE METAMORPHISM IN THE CENTRAL HOHE TAUERN ?

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We have studied muscovite gneisses which occur as intercalations within the amphibolites of the Zwölferzug formation, between the Felbertal and the Stubachtal. Such rocks have been mapped as "Muskowitaugengneis" by [1] and [2], while [3] introduced the name muscovite-plagioclase gneisses. Based on zircon typology investigations, [3] considered the gneisses as the metamorphosed products of highly fractionated granitoids. [4] presented concordant SHRIMP zircon ages of 374 ± 10 Ma for one sample, described as a high- to medium-K, I-type granodiorite. They interpreted the dated rock as a potentially subduction related, early-Variscan I-type granitoid. On the other hand, it seems clear that the rocks must have experienced a strong, probably Variscan, high-grade metamorphic overprint, like their amphibolitic host rocks. [1] described a pre-Alpine metamorphic paragenesis with plagioclase, K-feldspar, garnet and coarse muscovite. Relics of garnets, although mostly totally transformed into chlorite, could often be observed also in our samples.

We have analysed twenty samples of these gneisses by XRF methods. Major element compositions are intermediate to felsic ($SiO_2$ 60–70 wt.%, $Fe_2O_{3tot}$ 5–7 wt.%, MgO 2–3 wt.%) and broadly granodioritic ($K_2O$ 1–3 wt.%, $Na_2O$ around 3 wt.%). However, when compared to other Variscan I-type granodiorites (e.g. [5, 6, 7]), the CaO contents are remarkably low (often below 1 wt.%). Furthermore, the gneisses have unusually high A/CNK ratios (often > 1.8 !). Clearly, the rocks do not show a typical granitoid major element composition, and are either no magmatic rocks at all (metasediments ?), or were affected by severe chemical alteration. If the latter was the case, then the major phase of chemical alteration must have occurred prior to the Alpine orogeny, because the preserved pre-Alpine mineral paragenesis with many big muscovites is already indicative of a strongly peraluminous rock composition.

The trace element spectrum of the rocks is characterised by high Cr (100–200 ppm) and high Ni contents (30–60 ppm), low Rb (< 50–100 ppm) at moderate Sr contents (100–200 ppm), and high Ba (500–1000 ppm). These trace element patterns would rather fit to a paragneiss than a felsic granitic rock (see e.g. [8]). LREE concentrations are 30–100 times enriched relative to chondrite, the HREE and Y are less enriched ($Y_N$ 10–20). Nb varies between 10 and 15 ppm, Zr between 150 and 200 ppm.

Interestingly, several of the gneisses contain big accessory monazite. A pre-Alpine generation of monazite shows secondary coronas consisting of apatite, allanite and epidote [9], a younger generation of small monazites grew during the Alpine metamorphic overprint. Chemical dating by means of the electron microprobe yielded a weighted average age of 373 ± 15 Ma (95 % CL) for the older monazite generation (Fig. 1).

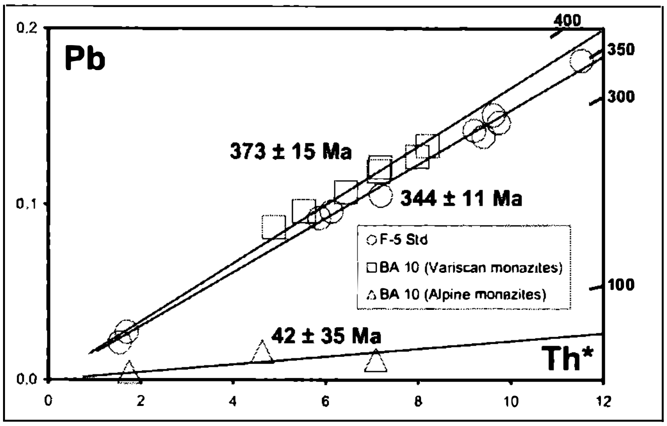


*Fig. 1*
*Total Pb vs. Th* isochron diagram after [12] using the values listed in Tab. 1. Time scale shown is based on the position of zero-intersect isochrons. Drawn isochrons refer to the calculated weighted average ages for the two monazite age groups in sample BA 10 and the monazite standard F5 (recommended age 341 ± 2 Ma).*

| | $La_2O_3$ | $Nd_2O_3$ | $Y_2O_3$ | Th | U | Pb | Th* | Age | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12,63 | 10,87 | 0,60 | 4,306 | 0,100 | 0,016 | 4,627 | **78** | ± | **117** |
| 2 | 14,42 | 11,24 | 0,67 | 1,454 | 0,093 | 0,005 | 1,751 | **59** | ± | **155** |
| 3 | 12,26 | 10,53 | 1,11 | 6,587 | 0,156 | 0,012 | 7,084 | **37** | ± | **38** |
| 4 | 13,07 | 12,84 | 0,04 | 2,953 | 0,789 | 0,096 | 5,530 | **390** | ± | **49** |
| 5 | 12,94 | 12,91 | 0,02 | 3,304 | 0,959 | 0,107 | 6,431 | **373** | ± | **42** |
| 6 | 12,78 | 12,33 | 0,04 | 4,163 | 1,171 | 0,127 | 7,978 | **358** | ± | **34** |
| 7 | 12,86 | 12,61 | 0,01 | 4,058 | 0,957 | 0,121 | 7,181 | **378** | ± | **37** |
| 8 | 12,99 | 12,68 | 0,05 | 4,403 | 1,165 | 0,133 | 8,203 | **365** | ± | **33** |
| 9 | 12,99 | 13,10 | 0,02 | 3,826 | 1,018 | 0,119 | 7,148 | **373** | ± | **38** |
| 10 | 13,53 | 13,23 | 0,05 | 2,673 | 0,675 | 0,087 | 4,879 | **400** | ± | **55** |

*Tab. 1*
*Chemical characteristics (wt.%) and Th-U-Pb model ages of monazites from sample BA 10. Errors on the age are 2σ. Th* values calculated after [12]. Note the extremely low $Y_2O_3$ contents of the Variscan monazites and the systematically higher Y contents and Th/U ratios (low U) of the Alpine monazites (analyses 1-3).*

This age is practically identical to the zircon age published by [4] for another sample of this gneiss unit. However, since their yttrium contents were always extremely low (Tab. 1), we believe that the c. 370 Ma old monazite relics grew in paragenesis with garnet and, therefore, probably date an early Variscan high-grade metamorphic event. Alternatively, if the monazites are magmatic and their host rock granitic with a c. 370 Ma intrusion age, then this granite should have had an unusual mineralogy involving considerable amounts of magmatic or restitic garnet. Zircons separated from the same sample (BA 10) are rounded and do not look like granite-zircons. They may eventually be detrital in origin. However, zircons from granulitic rocks often show such morphological features as well [10]. Therefore, it is also at issue whether the zircon age published by [4] perhaps dates an early-Variscan, high-grade, possibly even granulite-facies metamorphic event in the Zwölferzug.

Likewise it should be checked, if some of the Devonian/Early Carboniferous zircon ages recently reported from basement units of the central Hohe Tauern [11] could not be interpreted as metamorphic ages as well. Furthermore, we need to investigate, if there is evidence of a (second?) phase of Variscan metamorphism in the Zwölferzug formation or other parts of the Stubach complex posterior to 370 Ma, i.e. in the Carboniferous, as may be indicated by c. 320 Ma K-Ar ages of amphiboles [1].

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