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SHORT COMMUNICATION

The Gemeric S-type granites in southeastern Slovakia: Late Palaeozoic or Alpine intrusions? Evidence from electron-microprobe dating of monazite

by *Fritz Finger*[1] and *Igor Broska*[2]

Abstract

The method of total-Pb monazite dating by means of the electron microprobe has been applied to broadly constrain the age of granite samples from the Gemeric tectonic unit in southeastern Slovakia. The aim was to determine whether these granites intruded in the late Palaeozoic or during the Alpine orogeny in the Cretaceous. Both views are currently held in the geological literature. Monazites from three different localities consistently yielded Permian Th-U-Pb model ages, with weighted averages for single samples at 272±11 Ma, 276±13 Ma and 273±13 Ma. The results thus suggest that the S-type granites of the Gemericum formed essentially in mid-Permian times.

Keywords: Carpathians, Slovakia, Gemericum, granites, monazite, geochronology.

Introduction

The Gemericum represents the southernmost basement-bearing tectonic unit of the Inner (BIELY et al., 1996), or Central (MAHEL', 1986; PLAŠIENKA et al., 1997) Western Carpathians. During the Alpine orogeny, it was thrust onto the Veporicum (Fig.1). The Gemericum itself includes several internal thrust sheets. It is uncertain whether these formed during Alpine or pre-Alpine deformational events. According to GRECULA (1982), a phase of intra-Gemeric nappe stacking may have occurred in the Permian. Lithologically, the Gemericum consists mainly of polymetamorphic Lower Palaeozoic strata, with basic to intermediate volcano-sedimentary formations in the north (Klatov and Rakovec groups) and volcanogenic flysch-type metasediments in the south (Gelnica group). Variscan regional metamorphism reached amphibolite facies conditions in the Klatov group and greenschist facies grade in the Rakovec and Gelnica groups (KRIST et al., 1992; FARYAD, 1997). Alpine metamorphism was generally at lower greenschist facies grade.

Tin-bearing S-type granites intruded into the folded Variscan basement. Although only small surface exposures are present (e.g. PETRIK and KOHÚT, 1997), geophysical data and boreholes suggest that large masses of these granites are hidden below the metavolcanics and metasediments (VOZÁR et al., 1996). According to field evidence, at least some of the granites were included in the internal Gemeric nappe system, and their intrusion ages thus constitute important time limits for this thrust tectonics (GRECULA, 1982, 1995).

In the past, a Permian age has been assumed for the Gemeric granites, relying on Rb-Sr whole-rock isochrons (KOVACH et al.; 1986, CAMBEL et al., 1989). However, a recent deep seismic profile has revealed structures which are interpreted in favour of an important Alpine (Cretaceous?) plutonic event in the Gemeric unit (VOZÁR et al., 1996). Transparent and (due to their small amplitude) indistinct seismic zones in the upper crust were regarded as (syn-collisional) granitoid bodies intruded into the Alpine structures. This has raised some doubts concerning the reliability of the Permian Rb-Sr whole-rock ages obtained from the surface exposures of Gemeric granites (VOZÁROVA and VOZÁR, 1996), all the more so as Rb-Sr and K-Ar muscovite dating provided mostly Alpine values for these rocks (KANTOR and

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RYBÁR, 1979). The Permian ages still await confirmation through dating of high-T minerals like zircon or monazite.

In this paper, we present chemical Th–U–Pb model ages of monazites from three samples of Gemeric granites. Two samples were obtained from the northwestern part of the Gemericum (Hnilec body), whilst one comes from the southwestern corner of the unit (Betliar body). This latter granite body has been considered as the most potential candidate for an Alpine-age intrusion from geological reasoning, considering the seismic data (VOZÁR et al., 1996; VOZÁROVA and VOZÁR, 1996).

The dated samples

Granite samples GZ-1 and GZ-3 are medium-grained, whilst GZ-15 is coarser grained with phyric K-feldspar (for sample localities, see Fig.1). Apart from large amounts of perthitic K-feldspar, oligoclase and quartz, the rocks contain some muscovite and rare biotite. Accessory phases are zircon, monazite, apatite, xenotime, rutile, garnet and tourmaline. All three samples show a severe mylonitic low-T overprint and are in the strict sense metagranites, a feature which holds true for the Gemeric granites in general (PETRIK and KOHÚT, 1997). Geochemically, all three samples can be described as S-type granites. As is typical for the Gemeric granite suite (e.g. BROSKA and UHER, 1998), they are high in SiO_2 (~ 70%), strongly peraluminous (A/CNK ~ 1.3) and rich in phosphorus.

Dating results

Several recent studies (e.g. COCHERIE et al., 1998 and further references therein) have shown that chemical Th-U-Pb dating of monazite by means of the electron microprobe is a useful geochronological tool, as it provides moderately precise monazite crystallization ages. The theoretical basis of the method, its advantages and major error risks can be taken from the work of MONTEL et al. (1996). The analytical procedure used in the pre-

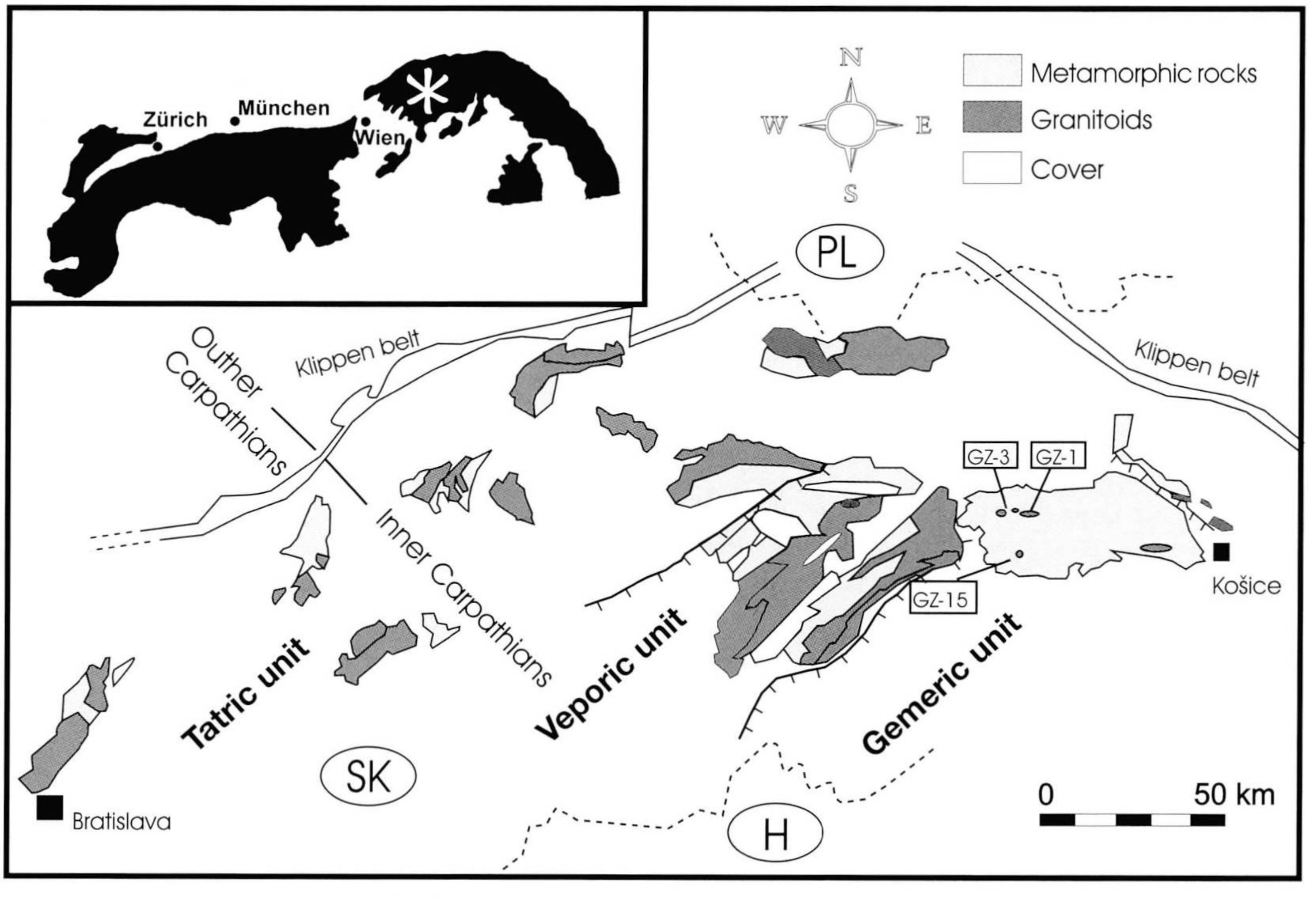

Fig. 1 Geological sketch map of the Western Carpathians showing the major basement massifs and the sample localities of this study (GZ-1: Hnilec, cliff 780 m above sea level, 800 m NE from elevation point Peklisko; GZ-3: Hnilec, outcrop 1205 m above sea level, 220 m NE from elevation point Surovec; GZ-15: Betliar, cliff 3250 m SW from elevation point Volovec II). Inset shows the position of the map area (white star) in the Alpine-Carpathian chain.

Tab. 1 Th, U, Pb contents (wt.% elements), Th* values and model ages of the analysed monazites from samples GZ-1, GZ-3 and GZ-15. Model ages and 2σ errors were calculated after the method of MONTEL et al. (1996), Th* values have been recast with these model ages using the equation given in SUZUKI et al. (1991). For each sample, a weighted average age (95 % c.l.) is given.

Grain	Th	U	Pb	Th*	Age
	SAMPLE GZ-1				
m1	10.618	0.762	0.149	13.082	**256 ± 24**
m2	11.489	1.213	0.192	15.419	**279 ± 20**
m3	13.340	1.371	0.219	17.779	**276 ± 18**
					272 ± 11
	SAMPLE GZ-3				
m1	2.714	0.057	0.029	2.898	**228 ± 108**
m2	12.550	1.416	0.207	17.134	**271 ± 18**
m3	10.732	0.980	0.179	13.910	**289 ± 23**
m4	2.583	0.048	0.038	2.740	**307 ± 114**
m5	3.243	0.061	0.042	3.441	**272 ± 91**
m6	3.298	0.066	0.045	3.510	**285 ± 90**
m7	3.556	0.036	0.038	3.672	**234 ± 86**
					276 ± 13
	SAMPLE GZ-15				
m1	6.377	0.123	0.075	6.775	**249 ± 46**
m2	9.166	0.664	0.145	11.317	**287 ± 28**
m3	9.203	0.683	0.133	11.414	**262 ± 28**
m4	10.145	1.299	0.170	14.349	**266 ± 22**
m5	17.049	1.462	0.273	21.786	**281 ± 14**
m6	9.613	0.421	0.124	10.974	**254 ± 29**
					273 ± 13

sent study follows the working routine in the Salzburg laboratory, described in FINGER and HELMY (1998).

Monazites were located in normal polished thin sections by means of BSE imaging. All three samples contained several monazite grains per thin section, the largest of which were chosen for analysis. The analyses were carried out with a defocused beam (5 μm), which was generally placed into the grain centres. This was done to avoid potential lead loss effects which may occur at the rim zones of monazite (SUZUKI et al., 1994). The risk of picking up inherited lead in the core zones was considered minor, due to the fractionated nature of the granites and the relatively high proposed magma temperatures of around 750–800 °C (PETRIK and KOHÚT, 1997). Additionally, BSE imaging provided no evidence of inherited cores. The Th, U, Pb concentrations and calculated model ages with errors (2σ) are given in Tab.1. Using an accelerating voltage of 15 kV, a probe current of 250 nA and counting times of 200 s for Pb (Mα), 50 s for U (Mα) and 30 s for Th (Mα), the 2-sigma errors and detection limits resulting from the counting statistics of the microprobe were typically 0.011 wt.% for Pb, 0.03 wt.% for U and 0.04 wt.% for Th.

In figure 2 the results are graphically presented in a Th* vs Pb diagram, together with data for a monazite age standard. This standard was used to independently control the analytical accuracy of the dating procedure (FINGER and HELMY, 1998). In the Th* vs Pb diagram, monazites of one age should plot along a straight line through zero, given that common lead contents and lead loss were unimportant. The slope of this line is a direct function of the age. The Th* parameter has been calculated according to SUZUKI et al. (1991). It includes the measured Th plus a certain amount of theoretical Th, that would have produced the same amount of lead as the measured U (at the model age).

The thin section of *sample GZ-1* contained only three monazites of sufficient size. These had high brabantite components ($CaTh[PO_4]_2$), and thus gave well defined model ages between 256 ± 24 Ma and 279 ± 20 Ma (weighted average age: 272 ± 11 Ma). In *sample GZ-3*, seven grains were analysed. Most had rather low Th contents and, consequently, low contents of radiogenic lead and large errors in the age calculation (Tab. 1). Two high-Th grains provided ages of 271 ± 18 Ma and 289 ± 23 Ma, respectively. The weighted average

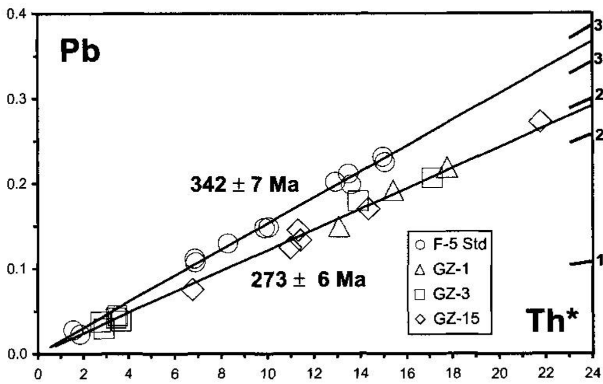

Fig. 2 Total Pb vs. Th* isochron diagram after SUZUKI et al. (1991) using the values given in Tab.1. Also shown are data from laboratory standard F-5 obtained during the same analytical session. The F-5 monazites were taken from a fraction, which was dated by U-Pb isotope dilution – mass spectrometry techniques at a concordant age of 341 ± 2 Ma (FRIEDL, 1997). The recommended age could be perfectly reproduced (weighted average: 342 ± 7 Ma; MSWD 0.54). The time scale shown is based on the position of zero-intersect isochrons. The two drawn isochrons refer to the calculated weighted average of all sample and standard data points, respectively (95% c.l.). Size of symbols corresponds approximately to the ± 1σ error of the Pb analysis.

age of all seven analyses is 276 ± 13 Ma. Six grains were analysed in *sample GZ-15*. These had a Th* variation from ca. 7 to 22 wt% and gave consistent Permian model ages, clustering around a weighted mean of 273 ± 13 Ma. The linear Th*-Pb covariation of all data points and their trend towards zero (Fig. 2) argues against substantial lead loss or inheritance effects, and also against the presence of large amounts of common lead. Therefore, we assume that the model ages correspond more or less to the magmatic crystallization ages of the monazites.

Conclusions

The obtained monazite model ages lend support to the classic concept that the tin-bearing Gemeric S-type granite suite has a Permian formation age (see e.g. CAMBEL et al., 1989). Also, the Betliar granite in the south is obviously a Permian intrusion. Our data suggest that these Gemeric S-type granites formed at ca. 270 Ma, which means at a time when large parts of the Palaeozoic basement in the Carpathians and Alps underwent a phase of rifting (VOZÁR, 1997; NEUBAUER et al., 1999). High heat flow at this time apparently caused melting of lower-crustal metasedimentary sources. Later, the granites were incorporated into the nappe system of the Gemeric unit. However, the new age data for the granites provide no information as to whether this happened in the mid/late Permian or during the Alpine orogeny. Furthermore, it cannot be ruled out, of course, that younger granite bodies of Cretaceous age are present in the upper crust as well and are not currently exposed at the surface.

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