Pb-Pb zircon ages for tourmaline alkali-feldspar orthogneiss from Hluboká nad Vltavou in southern Bohemia

Pb-Pb stáří zirkonu v turmalinické alkalicko-živcové ortorule od Hluboké nad Vltavou (Czech summary)

(2 *text-figs.*)

STANISLAV VRÁNA[1] – ALFRED KRÖNER[2]

[1] *Czech Geological Survey, Klárov 3, 118 21 Praha 1, Czech Republic*
[2] *Institut für Geowissenschaften, Universität Mainz, 55099 Mainz, Germany*

The pre-Variscan tourmaline-bearing orthogneiss occurring near Hluboká nad Vltavou, southern Bohemia, is tectonically intercalated in sillimanite-biotite paragneisses of the Monotonous Unit of the Moldanubian Zone and is a metamorphosed biotite-muscovite alkali-feldspar granite with a composition comparable to pegmatite. Zircons from a sample of this orthogneiss were dated by single grain evaporation and yielded a mean $^{207}Pb/^{206}Pb$ age of 508±7 Ma which we interpret to approximate the time of granite emplacement. One xenocrystic zircon grain with a $^{207}Pb/^{206}Pb$ age of 606±8 Ma either suggests derivation of the granite by anatexis from a late Precambrian crustal source or digestion of such material during ascent and/or emplacement of the granite. The emplacement age is similar to zircon ages for granitoid gneisses exposed in the Orlické hory Mts. and the Śnieznik Dome and may suggest that Ordovician granitoid activity was widespread in the southern and eastern Bohemian Massif.

Key words: Pb-Pb zircon ages, tourmaline alkali-feldspar orthogneiss, southern Bohemia, Moldanubian Zone

Introduction

The Moldanubian Zone in southern Bohemia contains nearly a dozen types of orthogneisses with distinct and contrasting petrography and geochemistry. The tourmaline-bearing orthogneisses of the Blaník type occur as several km long bodies scattered over south-central, southern and eastern Bohemia (Němec 1980, Klečka et al. 1992). The orthogneiss north of Hluboká nad Vltavou, 10 km north of České Budějovice, is the largest unit of this type among about ten similar occurrences.

Geological setting

The orthogneiss near Hluboká nad Vltavou is a sheet-like body, 7 by 2 km in outcrop size, with a true thickness of about 1 km. It occurs structurally conformably or semi-conformably in sillimanite-biotite paragneisses of the Monotonous Unit. Since the foliation in the enclosing paragneiss corresponds largely to the third generation planar fabric produced by regionally widespread shearing and recrystallization in the amphibolite facies (Vrána et al. 1980), primary (intrusive) relationships between the orthogneiss protolith and the paragneisses are not preserved. The two rock units shared a common structural and metamorphic evolution since emplacement of the orthogneiss.

The orthogneiss

The rock is medium-grained, has a distinct foliation and a linear fabric, sometimes accentuated by oriented tourmaline prisms up to 3 cm long or, alternatively, tourmaline forms granular aggregates. Quartz, microcline in part perthitic, albite, Fe-rich biotite, and a weakly phengitic muscovite are the main constituents. Besides minor tourmaline there are accessory minerals including apatite (near 1 vol. %), garnet (almandine containing 14-21 mol. % spessartine and minor admixtures of grossular and pyrope), sillimanite, monazite, sphalerite, gahnite, and zircon. The existing information indicates that the orthogneiss is a metamorphosed tourmaline-bearing biotite-muscovite alkali-feldspar granite with a composition comparable to pegmatite (Vrána et al. 1980, Povondra – Vrána 1993).

With Rb contents (in ppm) ranging from 300 to 500, Sr from 10 to 40, and Sn from 10 to 40 the rock is comparable to so-called tin-bearing granites (Štemprok 1979). The compositional variability is rather limited. Based on geochemical data, the rock can be compared to granites derived from a crustal source in a syncollisional tectonic setting (Slabý 1991).

Zircon analysis

Zirconium abundance in the orthogneiss typically ranges from 15 to 50 ppm and resulted in a rather

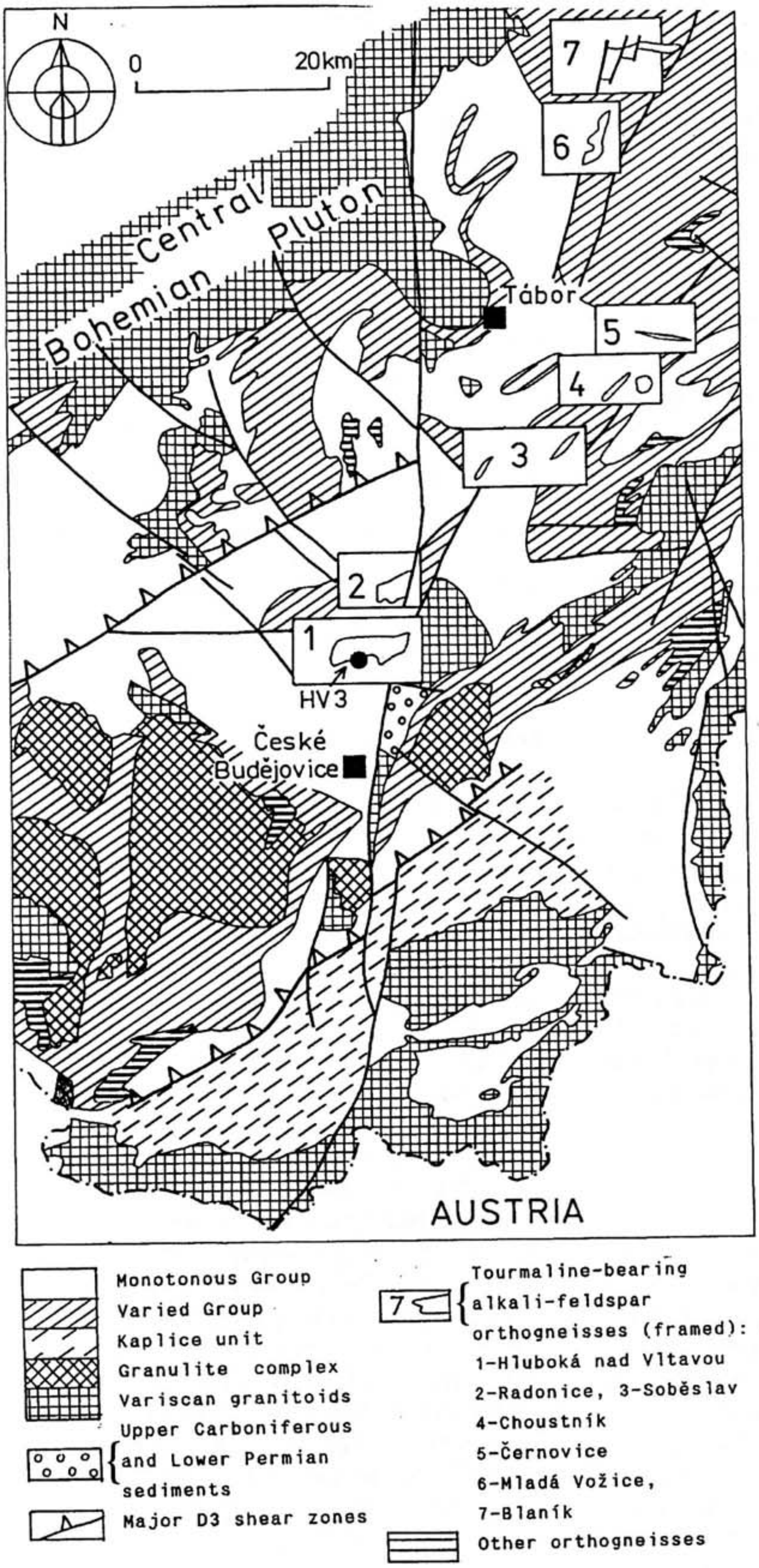

Fig. 1. Occurrences of tourmaline-bearing alkali-feldspar orthogneisses in the Moldanubian Zone of southern Bohemia and location of the dated sample HV 3

low zircon content. We obtained a zircon concentrate by processing a 30 kg sample from a roadcut 80 m east of the confluence of the Libochovka brook with the Vltava River, near the main road from Hluboká nad Vltavou to Poněšice. The zircon crystals are largely euhedral, mainly 50 to 250 μm long. There is a range of crystal habits from equant to prismatic, with a predominance of the latter and typical width/length ratios near 1:5. This is comparable to morphologies of primary magmatic zircons generally found in two-mica granites (Pupin 1980). Most grains are colourless and transparent, but a few crystals are cloudy, and a few yellow to brownish grains are also present. Inclusions of older zircon cores were occasionally noted.

Seven single zircon grains were analyzed for Pb-isotopes, using the zircon evaporation method described by Kober (1986, 1987). The analytical details are described elsewhere (Kröner – Todt 1988, Kröner et al. 1991), and the results are presented in Table 1. All ages are given with standard error. Six idiomorphic grains were evaporated individually and yielded comparable $^{207}Pb/^{206}Pb$ ratios which provide a mean $^{207}Pb/^{206}Pb$ age of 508±7 Ma (Table 1, Fig. 2a). One further grain with rounded terminations returned significantly higher Pb isotopic ratios and a mean $^{207}Pb/^{206}Pb$ minimum age of 606±8 Ma (Fig. 2b). Zircons in quartzo-feldspathic magmatic rocks subjected to amphibolite facies metamorphism generally retain the isotopic information of primary crystallization (Williams et al. 1983), and we therefore consider the six euhedral grains to reflect the time of crystalliza-

Table 1. Isotopic Data from Single Grain Zircon Evaporation

Sample Number	Zircon colour and morphology	Grain	Mass scans[1]	Evaporation temp. in °C	Mean $^{207}Pb/^{206}Pb$ ratio[2] and 1-σ	$^{207}Pb/^{206}Pb$ age and 1-σ error
HV 3	thin, idiomorphic,	1	61	1597	0.05743±20	508±8
	long-prismatic, ends	2	62	1599	0.05745±22	509±8
	slightly rounded,	3	76	1590	0.05744±19	509±7
	clear to turbid	4	119	1604	0.05742±19	508±7
		5	137	1602	0.05745±15	509±6
		6	63	1600	0.05741±17	507±6
mean		1-6	518		**0.05743±18**	**508±7**
	turbid, rounded ends	7	94	1601	0.06007±22	606±8

[1]Number of $^{207}Pb/^{206}Pb$ ratios evaluated for age assessment. [2]Observed mean ratio for non-radiogenic Pb where necessary. Errors based on uncertainties in counting statistics.

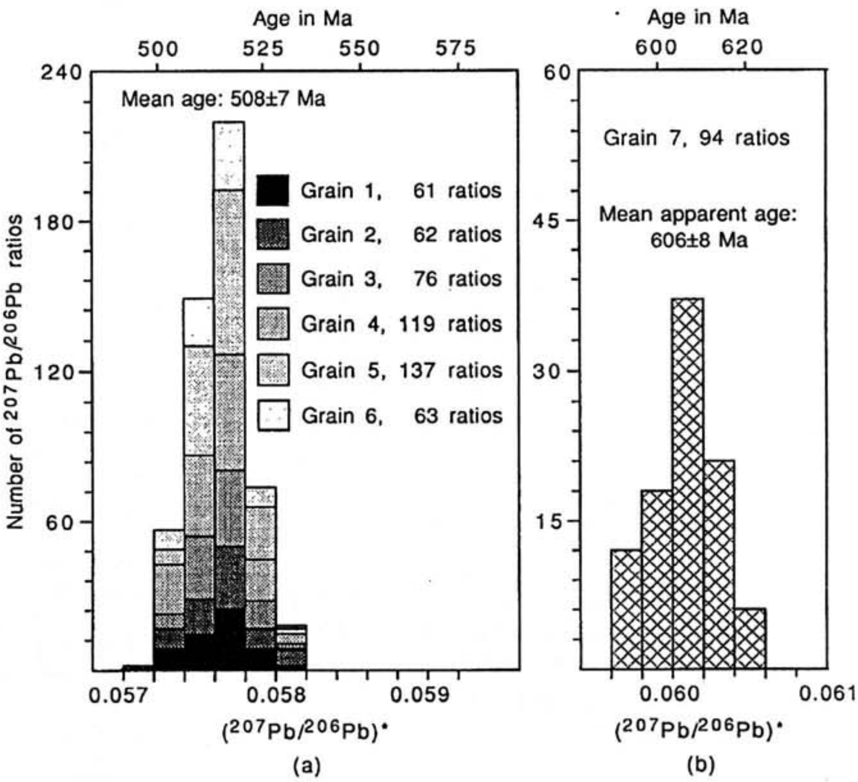

Fig. 2. Histograms showing distribution of radiogenic lead isotope ratios derived from evaporation of single zircons from granitoid orthogneiss sample HV 3, Hluboká nad Vltavou, southern Bohemia. (a) Spectrum for six grains, integrated from 518 ratios and interpreted to approximate age of magmatic emplacement of the gneiss precursor. (b) Spectrum for xenocrystic grain. Mean ages are given with standard error

tion of the original granite while the older grain is a xenocryst either representing the crustal source from which the tourmaline granite was derived through anatexis or some wall rock through which the granite magma ascended during emplacement.

Interpretation

There is no geological or mineralogical indication of a partial melting event during metamorphism of the orthogneiss that could have resulted in zircon overgrowth, and such overgrowth was also not observed under the microscope. A crystallochemical study of apatite in three orthogneiss samples by Povondra and Vrána (1993) indicates a refractory behaviour such that this mineral can be interpreted as primary magmatic apatite, essentially free of metamorphic recrystallization. Since zircon is notably more refractory than apatite, it is indeed unlikely that this mineral has been significantly affected by metamorphic recrystallization in sample HV 3.

We are therefore confident that the mean $^{207}Pb/^{206}Pb$ age obtained on six single zircon crystals approximates the time of magmatic crystallization of the original granite that was later transformed into orthogneiss. In view of the polyphase structural history of the Moldanubian complex, including regionally widespread crustal stacking during the Variscan event (Vrána 1979, Rajlich – Synek 1987, Matte et al. 1990), it is difficult to speculate at what time the granite was foliated and became structurally emplaced into the enclosing schists. The xenocryst age of 606±8 Ma may suggest that the granite was derived through anatexis of late Precambrian crustal material but could also mean that the granite digested crustal rocks of this age during ascent and/or emplacement.

Geological, petrographical and geochemical similarities between individual bodies of the Blaník type orthogneiss (Povondra et al. 1987, Klečka et al. 1992, Povondra – Vrána 1993) suggest that this orthogneiss and also the related Přibyslavice granite may have emplacement ages similar to the Hluboká orthogneiss. We also note that the above emplacement age is similar to zircon ages for granitic orthogneiss samples from the Orlické Hory Mts. and the Śnieznik Dome at the north-eastern margin of the Bohemian Massif (Kröner et al. 1994).

Recent Rb-Sr dating of Choustník orthogneiss (Rajlich et al. 1992), which gave whole-rock isochron age of 459±10 Ma, may reflect possible opening of the Rb-Sr isotopic system during superimposed shearing and metamorphism.

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Pb-Pb stáří zirkonu v turmalinické alkalicko-živcové ortorule od Hluboké nad Vltavou

Předvariská ortorula s turmalínem, vyskytující se s. od Hluboké nad Vltavou v jižních Čechách jako deskovité těleso 7 km dlouhé a 2 km široké, má tektonizované vztahy k okolním sillimanit-biotitickým pararulám jednotvárné jednotky moldanubika. Ortorula představuje metamorfovaný muskovit-biotitický alkalicko-živcový granit, jehož složení bylo blízké obecnému pegmatitu. Zirkony, vyseparované ze vzorku této ortoruly z odkryvu při soutoku Libochovky s Vltavou, byly analyzovány metodou odpařování jednotlivých krystalů a poskytly střední stáří $^{207}Pb/^{206}Pb$ 508±7 miliónů let. Toto stáří interpretujeme jako dobu intruze a utuhnutí původního granitu. Jeden krystal zirkonu s terminálním zaoblením, poměrem $^{207}Pb/^{206}Pb$ a stářím 606±8 miliónů let je pravděpodobně xenokryst, který může indikovat vznik granitu anatexí pozdně prekambrického krustálního zdroje, nebo pohlcení takového materiálu během výstupu či intruze granitu.
Geologicky, petrograficky a geochemicky podobná tělesa ortorul blanického typu i částečně podobný přibyslavický granit mohou mít pravděpodobně přibližné stáří jako datovaný vzorek ortoruly od Hluboké nad Vltavou. Zjištěné stáří zirkonu, a tedy původní intruze, je podobné jako stáří zirkonu v ortorulách z Orlických hor a sněžnické klenby, což naznačuje značný rozsah ordovického granitového plutonismu ve v. a jižní části Českého masívu.