Sr AND Nd ISOTOPIC DETERMINATIONS IN THREE MOLDANUBIAN GRANULITE MASSIFS IN SOUTHERN BOHEMIA

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We present Sr and Nd isotopic data of eight granulite samples from three Moldanubian granulite massifs in southern Bohemia: Blanský Les, Náměšť, and Lišov.

Sample	Description	SiO_2[%]	ε_{Nd}(*)	T_{DM}[Ga]	$^{87}Sr/^{86}Sr_i$
Blanský Les					
32	pyriclasite	56	-4.8	1.5	0.71259
36	enderbitic granulite	63	-6.1	1.5	0.71266
26	enderbitic granulite	68	-5.5	-	0.70996
26b			-5.5	-	
Náměšť					
GM-12	granulite	68	-7.0	1.5	0.71473
GM-6	granulitic gneiss	76	-4.8	-	0.76400
Lišov					
105	granulite				
		54	-2.3	1.2	0.70627
98	pyribolite	76	-4.9	1.3	0.73056
98b			-4.6	1.3	
102	melagranulite	76	-5.3	1.6	0.73005

* 338Ma, 1s precision ε_{Nd}(*) 0.15, $^{87}Sr/^{86}Sr_i$ 0.003%

nitial values have been calculated at 338 Ma, the age for early Carboniferous (?) (Namurian) development of granulite facies assemblages in southern Bohemia (Aftalion et al., 1989). The data show radiogenic $^{87}Sr/^{86}Sr_i$ values for the felsic granulites at the time of granulite metamorphism, indicating that these samples have experienced a prolonged crustal residence. Initial e_{Nd} variations do not correlate with SiO_2 content, and presumably reveal the isotopic heterogeneity resulting from the prolonged cnistal residence of the protoliths or the rocks themselves. The neodymium depleted mantle model ages (calculated using the equation of DePaolo), range between 1.2–1.5 Ga, corresponding to the "pan-European" age (ca. 1.5 Ga) found in many European Hercynian Massifs. These ages are model dependent, and imply that the Sm/Nd ratio did not change during granulite facies metamorphism, and that the rock or protolith was derived from the depleted mantle. Because of these assumptions, we suggest that the model ages of this preliminary study should be considered with caution.

Reference

Aftalion et al. (1989): N. Jb. Miner. Mh. H. 4,145–152

ZIRCON GROWTH AND RECRYSTALLIZATION DURING GRANULITE FACIES METAMORPHISM IN THE IVREA ZONE (SOUTHERN ALPS): A COMBINED CATHODOLUMINESCENCE AND ION MICROPROBE STUDY

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The U/Pb dating of zircon is indispensible for revealing the magmatic and metamorphic history of high-grade metamorphic terrains. It requires a proper understanding of the various internal growth morphologies and secondary structures in the crystals and their correlation with ionprobe isotopic data. A comparative study has been made in meta-sedimentary and meta-igneous granulites from the Ivrea zone lower crust where granulite metamorphism is known to have occurred at lower Permian time.

By means of cathodoluminescence imaging, the following types of internal growth structures and morphologies can be distinguished. Linear growth banding, like that commonly observed in granitoidal zircons, is found in the core of most crystals. Isometric (spherical) growth banding, which is partly curved (non-linear) and partly constituted of numerous unsteadily growing crystal faces with zig-zag sector boundaries (fir-tree sector zoning), either forms an overgrowth or is the only growth morphology present. According to the ionprobe data, this type of morphology has grown entirely during the lower Permian granulite metamorphism at ca. 280 Ma. Comparing meta-granitoidal and meta-sedimentary zircons, the proportions of granulitic overgrowths to magmatic cores are extremely different. In the meta-granitoid, the magmatic cores are large and euhedral, having only a thin granulitic overgrowth. Subsequent to the overgrowth, the crystals underwent partial dissolution giving rise to smooth spherical or ovoidal shapes and leaving granulitic overgrowths only in small remnants. In the meta-sediments, cores of detrital shape are small and have generally a thicker granulitic overgrowth, but a further differentiation can be made between adjacent leucocratic and melanocratic meta-sedimentary layers in the banded granulite. Zircons in the meta-pelitic dark layer (rich in garnet, orthoclase, and cordierite) are the most extreme, in that cores rarely exceed 10% in volume and many crystals have formed entirely by metamorphic growth. At distinct stages within this large granulitic growth interval, the growth morphology changes discontinuously from numerous unsteadily growing crystal faces to a reduced number of more steadily growing crystal faces. This latter type appears transitional to the familiar magmatic growth banding of granitoidal zircon. Due to analytical error, the ionprobe U/Pb data do not resolve an age difference between the two morphologically distinct intervals. Both are attributed to the lower Permian granulite metamorphism. In contrast to the meta-granitoidal zircons, the meta-sedimentary zircons have not undergone any dissolution event. The essence of the morphological study is that the potential for metamorphic growth was much greater in the meta-sediment as compared to the meta-granitoid. As both rock types have undergone equivalent granulite facies and anatectic conditions, the contrasting growth behavior of zircon reflects differences in mineralogy and original state of Zr distribution in the protoliths. In the meta-granitoid, most of the Zr has originally crystallized as magmatic zircon crystals resulting in little potential for metamorphic zircon overgrowth during granulite facies. The presence of partial crystal dissolution as the final event is best explained by the formation and extraction of an anatectic melt at the climax of metamorphism. In the meta-sediment, the detrital zircons did not crystallize in equilibrium with its present host rock. Especially in the meta-pelitic layer, the detrital zircon cores are very small and it can be assumed that part of the Zr was either deposited as small highly dissolvable zircon crystallites or was incorporated in layer silicates. These are the possible reservoirs for strong zircon growth during metamorphism. The absence of internal stages of remelting in the meta-sedimentary zircons is notable, because the mineralogy and chemistry of these rocks is strongly restitic suggesting the extraction of anatectic melt. If anatexis has occurred, it did not cause dissolution of zircon. A possible explanation is that the formation of melt in the meta-pelitic lithology is associated with the decomposition of biotite, which is a potential supplier of Zr for zircon growth. The observed morphological discontinuity in the metamorphic zircon overgrowth may coincide with the start of anatectic melting changing the growth environment of the crystals.

The primary growth structures of the zircon crystals of magmatic and metamorphic origin are both partly eliminated by secondary structures. Two types of secondary structures can be distinguished. The first one consists of highly luminescent volumes which are largely controlled and confined by primary growth structures, such as external and internal grain boundaries, inclusions, sector boundaries and primary growth bands. These volumes are extremely poor in U and Th (both less than 20 ppm). They result from the recrystallization of pure zircon from both, impurity-rich magmatic and metamorphic zircon. Although the U/Pb data have large analytical errors due to the low amount of radiogenic Pb, they indicate a postgranulitic recrystallization at ca. 220 Ma of parts of the metamorphic overgrowths.

A different type of secondary structure is observed as wavy and curly bands ressembling ductile flow structures. As opposed to recrystallization, these structures are not controlled by pre-existing growth morphologies. They are not depleted in U and Th and yield U/Pb data coinciding with those of the granulitic overgrowths. These flow structures have only been observed in granulitic zircons. They probably result from volume diffusion requiring temperatures only attained during granulite facies metamorphism.

GEOTECTONIC POSITION, PETROCHEMICAL AND GEOCHRONOLOGICAL FEATURES OF THE YOUNGER GRANITE COMPLEX IN THE KRUŠNÉ HORY (ERZGEBIRGE) OF THE BOHEMIAN MASSIF

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1. The Krušné hory (Erzgebirge) granite pluton occurs in the area of about 5 thousands square kilometres and it is formed by granites of the Older and the Younger complexes. The pluton is shallowly eroded .It is developed almost on the entire territory of the Krušné hory (Erzgebirge) and Smrčiny (Fichtelgebirge) anticlinorium of the Bohemian massif at different depths (not exceeding 1–2 km). According to the geophysical data, granites are continuing into the crust to the depths of 8–15 km. Deeper they merge with a giant plate-like body of granitoid composition which according to the seismic data is localized within the granulites of the lower sialic crust at the depths from 8 to 18 km. It is suggested that this granitoid body represented an anatectic magmatic reservoir with a total volume of not less than 30.000 cubic kilometers from which granites of the Krušné hory (Erzgebirge) pluton were generated.

An intrusive-anatectic granitoid system is localized at the intersection of the closely spaced faults which penetrated into the mantle and formed transcontinental lineaments of north-east and north strike.

2. The comagmatic series of the Younger and the Older complexes were formed due to the evolution of closely associated in time and space deep-seated granitoid anatectic sources. The Older granite complex is formed mainly by biotite and two-mica granites of standard geochemical type. Among the granites of the Younger complex lithium-fluorine leuco-granites occur. The magmatic differentiation has been most intense in the formation of the Younger complex whose end members are represented by rare metal albite-microcline-topaz granites. Their appearance points to the full evolution of the magmatic differentiation and to the possibility of separation of ore bearing solutions from a magmatic reservoir . According to present studies the fluorine content in these solutions was in the range up to 0.n %, and that of lithium, tin and uranium up to 0.00n %.

3. Rb-Sr isotope dating of the Eibenstock intrusive body of the Younger complex was carried out separately for granites of the first and second intrusion phases. In total 11 whole rock samples of the first phase have yielded the isochron with T = 305 ± 2 Ma and $(^{87}Sr/^{86}Sr)_0$ = 0.7122 ± 0.0015. Two other isochrons (plagioclase, biotite, whole rock) showed very close results 305 ± 3 Ma, 0.7113 ± 0.0034 and 303 ± 4 Ma, 0.7118 ± 0.009O. This indicates a complete closeness of Rb-Sr isotope system of the granites after their formation. For granites of the second phase (7 whole rock samples) the isochron shows T = 299 ± 3 Ma, $(^{87}Sr/^{86}Sr)_0$ = 0.719 ± 0.016. The granites of the second phase have considerably higher Rb/Sr ratio and high content of radiogenic Sr (the $^{87}Sr/^{86}Sr$ ratio is up to 3.07). Therefore the estimate of the initial $^{87}Sr/^{86}Sr$ ratio obtained from an isochron is approximate. The data show close concurrent formation of two succesive intrusive phases. The value of 3–4 Ma can be accepted as an estimate of time for the body formation. The values of the initial $^{87}Sr/^{86}Sr$ ratio equal to 0.711 – 0.712, indicate that the granite magma was generated from relatively old sialic rocks of the continental crust.

4. Comparative analysis of the composition of Variscan granitoids in the Central and West-European provinces has shown that the magmatic differentiation processes had the highest intensity in the Krušné hory (Erzgebirge) and in the Central France massifs and a more limited intensity in the Central Bohemian massif.This could be one of the reasons for a different scale of the rare metal ore mineralization in these regions.