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Rb-Sr ISOTOPE STUDIES IN THE GARBY IZERSKIE ZONE - EVIDENCE FOR THE KARKONOSZE INTRUSION ACTIVITY

Abstract: The isotope age of 302 Ma (Westphalian) for skarn and the isotope age of 333 ± 4 Ma (Visean) for hornfelsed schists from the Garby Izerskie Zone were obtained. Magma not younger than 333 ± 4 Ma was the source of heat, which generated thermal front in the northern exocontact of the Variscan Karkonosze intrusion. Contact metamorphism, silicification and late hydrothermal alteration in the Garby Izerskie Zone were genetically related to the activity of the Karkonosze pluton.

Keywords: Rb-Sr isochron, skarn, hornfelsed schists, Garby Izerskie Zone

GEOLOGY

The Garby Izerskie Zone is of considerable geochronological interest because here the complex interaction of regional metamorphism, deformation, contact metamorphism, silica metasomatosis and fluorine metasomatosis can be observed. This zone developed between the Izera gneisses and the hornfelsed schists in the northern exocontact of the Karkonosze pluton. The investigated area is the 'Stanisław' quarry, located in the Garby Izerskie Zone. The SE wall-rocks of this quarry consist of hornfelsed schists with intercalations of skarns (Kozłowski 1978, Fila-Wójcicka 2000). The Garby Izerskie Zone is mineralised with quartz (Kozłowski 1978), and a continous increase in quartz content can be observed in both the gneisses and hornfelsed schists toward the centre of this zone, to form an almost monomineralic quartz rock (Kozłowski 1978). The rocks of the Garby Izerskie Zone are cut by non-silicified granitoid apophyses. The skarns, fractured hornfelsed schists and granitoid apophyses were subjected to the activity of F-bearing solutions (Kozłowski 1978).

SELECTION OF SAMPLES

During the fieldwork in 1998 at the 'Stanisław' quarry, 22 samples of the skarns and hornfelsed schists were collected from the freshly exposed SE wall of the quarry. The sample of the skarn selected for analysis consisted of the following minerals: wollastonite (95% of the sample), pyroxene, post-wollastonite calcite, and quartz xenoblasts. The samples of the hornfelsed schists selected for analysis were not taken from the contact between the granitoid apophyses and the hornfelsed schists. Indications of fractures and activity of F-bearing solutions were not observed. All samples were intensively silicified, but the lamination of the rock

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was observed. These hornfelsed schists were consisted of the following minerals: quartz (commonly with microlites of muscovite, biotite and andalusite), biotite, andalusite, muscovite, microcline and plagioclase. Negligible quantities of post-cordierite pinite and sericite were also present.

ISOTOPIC ANALYSES

The samples were carefully crushed in a jaw breaker and ground in a ball mill. All samples were then dissolved in HNO_3+HF+HCl solution and Sr and Rb were separated on chromatographic columns. Rb and Sr concentrations were determined by the isotope dilution method. The isotope ratios were measured on a VG Sector 54 mass spectrometer. A value of $^{86}Sr/^{88}Sr = 0.1194$ was used to correct for ion beam fractionation. During Sr isotope analysis the NBS SRM 987 standard was measured yielding an average ratio of $^{87}Sr/^{86}Sr = 0.710255 \pm 0.000011$.

The results of the isotopic analysis are listed in Table 1.

Table 1. Analytical data of the Rb-Sr whole-rock analyses for the skarn (S1, S1a, S1w) and hornfelsed schists (H1, H2, H3) from the 'Stanisław' quarry

sample	$^{87}Sr/^{86}Sr$ (corr)	error [%]	Rb [ppm]	Sr [ppm]	$^{87}Rb/^{86}Sr$
SS1	0.71699	0.0033	34.44	1.04	0.0861
S1a	0.717143	0.0032	25.07	1.15	0.1296
S1w	0.716592	0.0027	0	0	0
H1	0.760131	0.0025	50.6	189.5	10.6247
H2	0.765932	0.0019	43.2	181.0	11.9038
H3	0.715743	0.0035	71.1	32.7	1.3011

The Rb-Sr isochron for the skarn (Fig. 1A) based on three points representing one sample (S1) yields an age of 302 Ma (Westphalian) and an initial $^{87}Sr/^{86}Sr$ ratio of 0.716599. Radiometric analyses were performed on this sample for the whole rock (S1), for the > 0.09 fraction of the whole rock (S1a) and for the wollastonite (S1w). Wollastonite does not contain Rb, so its $^{87}Rb/^{86}Sr$ isotope ratio was equal to zero. The isotope age of 302 Ma was calculated from a best fit curve to three points, obtained using the least squares method. The error was not possible to obtain due to fact that the points lay too close to one another (see Fig. 2).

The Rb-Sr isochron for the hornfelsed schists of the Garby Izerskie Zone (Fig. 1B) based on three points representing three whole rock samples (H1, H2, H3) yields an age of 333 ± 4 Ma (Visean) and an initial $^{87}Sr/^{86}Sr$ ratio of 0.709567.

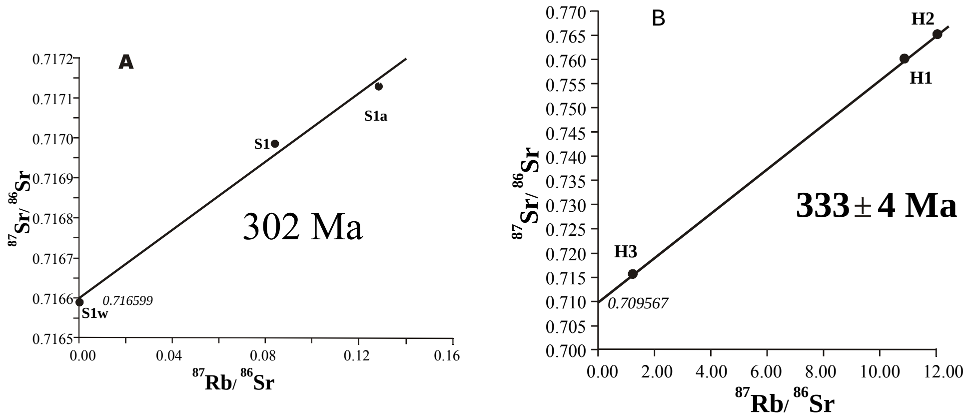

Fig 1. Rb-Sr isochron diagrams for the rocks from the Garby Izerskie Zone: A: For the mineral-whole rock of the skarn; initial $^{87}Sr/^{86}Sr$ ratio: 0.716599. B: For the whole rock of the hornfelsed schists; initial $^{87}Sr/^{86}Sr$ ratio: 0.709567

DISCUSSION AND CONCLUSIONS

Contact metamorphism in the Garby Izerskie Zone is documented by the skarns and hornfelsed schists. The maximum temperature of the formation of the hornfelsed schists (andalusite and cordierite formation) probably was below 600°C at 2 bkar (confront the p-T conditions of the following reaction: muscovite + quartz +biotite → andalusite + K-feldspar + cordierite + H_2O, Pattison & Tracy 1991). The maximum temperature of the formation of the skarns was ca. 650°C (wollastonite and grossular formation, Fila-Wójcicka 2000). Wollastonite and grossular formed at the temperature peak of contact metamorphism, i.e. at the time when temperature was between ca. 600 and ca. 650°C. Data from the metamorphic reactions that occurred in the hornfelsed schists and skarns during the prograde and retrograde contact metamorphism (Fila-Wójcicka 2000), i.e. before, during and after the thermal peak of contact metamorphism, suggest that silica-bearing solutions were present. In Fila-Wójcicka's (2000) opinion, the process of silicification could have partly overlapped the stages of contact metamorphism in time.

In the light of the temperature conditions of the formation of minerals in the Garby Izerskie Zone it follows that an age of the formation of the hornfelsed schists should be close to an age of the formation of the skarns. The isotope age of 333 ± 4 Ma (Visean) for the hornfelsed schists and the isotope age of 302 Ma (Westphalian) for the skarn are different. This mean that the Rb-Sr isochron clock for the hornfelsed schists started early then the Rb-Sr isochron clock for the skarn. The isotope age of 302 Ma for the skarn is younger than the isotope age of 333 ± 4 Ma for the hornfelsed schists (non-fractured samples) probably due to the isotopic homogenization during the late hydrothermal alteration overprint (most probably during the fluorine metasomatosis). In Kozłowski's (1978) opinion, the skarns, fractured hornfelsed schists and granitoid apophyses were subjected to the activity of F-bearing solutions.

In the light of the field observation in the Garby Izerskie Zone, the temperature conditions of the formation of minerals in this zone (quartz and fluorite formation, Kozłowski 1978, skarns formation, Fila-Wójcicka 2000, andalusite and cordierite formation) and the age of magma emplacement of the Karkonosze granite (see Duthou et al 1991, Marheine et al. 2002) it appears that the age of 333 ± 4 Ma for the hornfelsed schist is best interpreted as the cessation of contact metamorphism. From the isotopic analysis for these hornfelsed schist it follows that magma not younger than 333 ± 4 Ma was the source of heat, which generated thermal front in the northern exocontact of the Karkonosze intrusion.

Contact metamorphism was the last thermal event in the Garby Izerskie Zone. The age of 333 ± 4 Ma is close to the peak of contact metamorphism in this zone. This mean that contact metamorphism with conditions of temperature ca. 600-650°C and pressure ca. 2 kbar in the northern exocontact of the Karkonosze pluton was older than the biotite cooling at ca. 320 Ma obtained by Marheine et al. (2002).

The results of this study confirmed that contact metamorphism, silicification and late hydrothermal alteration in the Garby Izerskie Zone were genetically related to the activity of the Variscan Karkonosze pluton.

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