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**Ar-Ar DATING OF HORNBLENDE FROM PEGMATITE IN QUARTZ
MONZODIORITE FROM PRZEDBOROWA (LOWER SILESIA, POLAND) —
PRELIMINARY RESULTS**

Abstract. Hornblende separated from a pegmatite vein cutting quartz monzodiorite in the Przedborowa quarry was dated with the Ar-Ar method. After manual separation of the mineral from the disintegrated rock, the purity of the sample was verified by microscopic inspection of grain mounts and by IR spectroscopy. The obtained result (335.5 ± 5.0 Ma) is in agreement with other published ages of intrusive rocks of the Niemcza zone.

Key-words: Ar-Ar dating, hornblende, quartz monzodiorite, Przedborowa, Lower Silesia

INTRODUCTION

Hornblende is commonly used for determination of radiometric age with the K-Ar and Ar-Ar methods. Despite its low potassium content (usually below 2% K_2O), significantly lower than in K-feldspars or micas, hornblende is suitable for geochronological studies due to high retention of radiogenic argon in its mineral structure (Dickin 1995).

Hornblende from Przedborowa was analysed together with three other hornblende samples representing Tertiary and Mesozoic Carpathian rocks (Bukowski et al. 1997; Bukowski 1999; Dudek et al. 1999) with primary aim of additional verification of accuracy of the results. As the result obtained turned out to agree with some other age estimations of rocks from the Niemcza zone (Oliver et al. 1993; Lorenc 1998), it is presented here and discussed on the geological background.

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GEOLOGICAL SETTING

The Przedborowa quarry is situated *ca* 10 km NW from Ząbkowice Śl, between the villages Koziniec and Przedborowa. Geologically, it is in southern part of the Niemcza zone, the N-S elongated belt of metamorphic and igneous rocks bordered by the Sowie Mts block from the west and the Strzelin Hills from the east. To the south it is cut by the Marginal Sudetic fault, while to the north it plunges near Łagiewniki beneath Tertiary and Quaternary sediments. The geology of the area was exhaustively presented by Dziedzic (1963, 1987).

Relatively small bodies of acid and intermediate plutonic rocks occur within the predominating in the area metamorphic rocks: amphibolites, mica schists, mylonites and serpentinites. A dark, fine-crystalline rock mined in the Przedborowa quarry, described as quartz monzonite (Puziewicz 1987, 1990), is considered to form a vein of *ca* 100 m in thickness within amphibolites and garnet amphibolites common in the SW part of the Niemcza zone (Dziedzic 1975). According to Puziewicz (1987) the quartz monzonite from Przedborowa as well as quartz syenite from nearby Piława Górna represent marginal parts of a gabbroidal intrusion altered by selective assimilation of surrounding metamorphic rocks. Basing on the Rb/Sr ratio, Lorenc (1998) concluded that the monzonite and syenite derived from contaminated tholeiitic magma.

SAMPLE DESCRIPTION AND PREPARATION

The analysed hornblende was separated from a coarse-crystalline, small vein cutting the quartz monzodiorite. Such veins, usually a few cm in thickness, more rarely up to 15–20 cm, are mainly composed of almost black, elongated hornblende prisms and white or pale grey feldspars. Euhedral and subhedral hornblende crystals are from a few mm up to 2–3 cm in length, whereas feldspars build anhedral aggregates of smaller crystals. Minor components are biotite flakes (up to 2–3 mm), anhedral quartz grains and fine pyrite crystals. The contact between the veins and surrounding quartz monzonite is usually sharp, the latter being distinctly finer-crystalline. Similar veins have been described in the quartz syenite from Piława Górna (Puziewicz 1987).

In thin sections green-brownish hornblende prisms are pleochroic from green to yellowish-brown. Most crystals have irregular edges and are coated with aggregates of pale-green, secondary hornblende. Some cleavage surfaces are filled with green, pleochroic chlorite. Hornblende crystals also contain fine laths (below 0.2 mm in length) of dark brown, practically opaque phase, seemingly an exsolution or alteration product. Feldspars, represented by orthoclase perthites and plagioclases, and sparse biotite flakes also display signs of slight alteration. The most abundant accessory mineral is sphene (Phot. 1), less frequent are fine crystals of apatite and zircon as well as isometric opaque crystals (most probably pyrite).

The hornblende for geochronological analysis was separated manually under binocular microscope from the rock disintegrated to below *ca* 1 mm. Only grains devoid of any visible intergrowths with other mineral phases were selected. A small fraction of

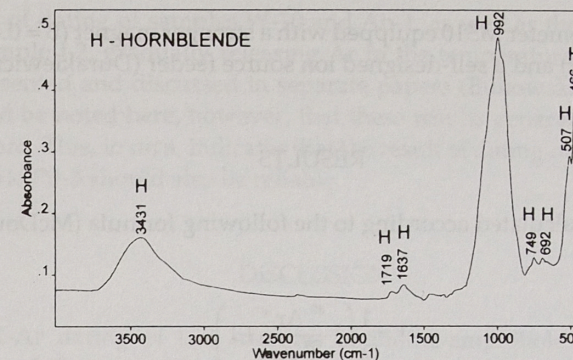


Fig. 1. IR spectrum of hornblende from Przedborowa (sample Pd-3)

the separated grains was crushed to below 0.1 mm and purity of this material was analysed by microscopic inspection of grain mounts as well as by IR spectroscopy. Microscopic observation revealed that practically all observed grains represented hornblende crystals, rare exceptions being only a few fine flakes of chlorite or biotite and isolated, colourless feldspar or quartz grains. The IR spectrum was recorded with a FTS BIO-RAD Model 165 spectrometer in the range 400–3800 cm^{-1} . The sample was prepared as a pressed tablet, composed of 1 mg sample and 300 mg KBr. Comparison of the spectrum obtained (Fig. 1) with the standard pattern (Moenke 1962) demonstrates that all significant peaks could be attributed to hornblende and no traces of other mineral phases have been noted.

EXPERIMENTAL

The sample from Przedborowa (Pd-3) was analysed together with two others (An-1 and W-10) separated from Miocene tuffs from the Carpathian Foredeep and one (J-2) representing hornblendite from the Ditrau Massif in the Inner Carpathians. The ages of the analysed samples were determined by the $^{40}\text{Ar}/^{39}\text{Ar}$ method at the Mass Spectrometry Laboratory, Maria Curie-Skłodowska University in Lublin. Aliquots of hornblende samples of about 60–80 mg each were wrapped in Al-foil and sealed in two air-evacuated silica-glass ampoules. The ampoules were irradiated in fast neutron flux of about $10^{13} \text{ cm}^{-2} \text{ s}^{-1}$ in the Maria reactor in Świerk (Poland). The samples Pd-3, An-1, J-2 and one aliquot of the standard (MMhb-1 hornblende) were irradiated during 55 hours, whereas the sample W-10 and the second aliquot of the standard were irradiated during 50 hours. After irradiation the ampoules were left in a lead container for a few weeks in order to reduce their activity. Then the samples were loaded in the extraction-purification line, where argon was released in steps in the interval 600 to 1300°C. The peaks of ^{36}Ar , ^{37}Ar , ^{39}Ar and ^{40}Ar were measured using static-vacuum mass spectrometry for each argon fraction extracted. The measurements were performed

with a mass spectrometer MS10 equipped with a stronger magnet (B = 0.44 T, produced by AMAG, Kraków) and a self-designed ion source feeder (Durakiewicz 1996).

RESULTS

The ages were calculated according to the following formula (McDougall, Harrison 1988):

$$t = \frac{1}{\lambda} \left(J \frac{{}^{40}\text{Ar}^*}{{}^{39}\text{Ar}} + 1 \right) \tag{1}$$

where $\lambda = 5.543 \cdot 10^{-10} \text{ a}^{-1}$ is the total decay constant of ${}^{40}\text{K}$, J is the neutron fluence parameter, ${}^{40}\text{Ar}^*$ is the quantity of the radiogenic argon released, and ${}^{39}\text{Ar}$ is the quantity of the argon obtained from the nuclear reaction ${}^{39}\text{K}(\text{n}, \text{p}){}^{39}\text{Ar}$.

The isotope ratio used in the formula (1) was calculated from mass spectrum peak ratios corrected for interfering nuclear reactions:

$$\frac{{}^{40}\text{Ar}^*}{{}^{39}\text{Ar}} = \frac{\left(\frac{{}^{40}\text{Ar}}{{}^{39}\text{Ar}} \right)_m - 295.5 \cdot \left(\frac{{}^{36}\text{Ar}}{{}^{39}\text{Ar}} \right)_m + 295.5 \cdot \left(\frac{{}^{37}\text{Ar}}{{}^{39}\text{Ar}} \right)_m \cdot a - c}{1 - \left(\frac{{}^{37}\text{Ar}}{{}^{39}\text{Ar}} \right)_m \cdot b} \tag{2}$$

where the measured peak of ${}^{37}\text{Ar}$ was corrected to radioactive decay, and a, b and c are corrections for the interfering reactions, taken after Dalrymple and Lanphere (1971). The fluence parameter J was estimated for both ampoules from the equation (1) on the basis of the known age ($520.4 \pm 1.7 \text{ Ma}$) of the MMhb-1 hornblende standard (Samson, Alexander 1987). For the first ampoule (irradiated 55 hours) we obtained the fluence parameter $J = 10.230 \cdot 10^{-3} \pm 0.10 \cdot 10^{-3}$, whereas for the second (irradiated 50 hours) $J = 9.199 \cdot 10^{-3} \pm 0.09 \cdot 10^{-3}$.

In the case of samples Pd-3, W-10 and An-1 significant amounts of argon were released at the temperature about 1200°C , in only one step. The results are presented in Table 1.

TABLE 1

Calculated ages of the analysed hornblendes

Sample	Fluence	${}^{40}\text{Ar}/{}^{39}\text{Ar}$	${}^{37}\text{Ar}/{}^{39}\text{Ar}^*$	${}^{36}\text{Ar}/{}^{39}\text{Ar}$	% ${}^{40}\text{Ar}_{\text{rad}}$	Age [Ma]
Pd-3	$10.230 \cdot 10^{-3}$	21.470	4.114	$6.309 \cdot 10^{-3}$	91.3	335.5 ± 5.0
W-10	$9.199 \cdot 10^{-3}$	1.685	5.490	$3.533 \cdot 10^{-3}$	38.0	18.0 ± 1.0
An-1	$10.230 \cdot 10^{-3}$	2.130	4.505	$5.972 \cdot 10^{-3}$	17.2	13.5 ± 1.0

* Ratio of ion currents corrected for decay of ${}^{37}\text{Ar}$ after irradiation ($T_{1/2} = 35.5 \text{ d}$).

The results of dating of samples W-10 and An-1, as well as the more complicated case of the sample J-2, gradually releasing Ar in the temperature range $600\text{--}1250^\circ\text{C}$, have been presented and discussed in separate papers (Bukowski 1999; Dudek et al. 1999). It should be noted here, however, that these results generally agree with other geological record. This, in turn, indicates that the result of dating of the simultaneously analysed sample Pd-3 should also be reliable.

DISCUSSION

The first K-Ar dating of two samples of biotite-amphibole concentrates from Przedborowa and Kořmin with the K-Ar indicated the ages of 276 Ma and 300 Ma, respectively, similar to the ages of samples from the Kłodzko-Złoty Stok granitoids (Depciuch 1972). More recent analysis of zircon grains from the Kořmice granitoids with the U-Pb method resulted in the age $388 \pm 4 \text{ Ma}$ (Oliver et al. 1993). On the basis of Rb-Sr isotopic studies of the intrusive rocks from the Niemcza zone, Lorenc (1998) concluded that although the examined rocks could not originate from one homogeneous source of magmas, they represent one cycle of Hercynian magmatic activity. Moreover, Rb/Sr isochrones obtained by this author fit in well with the results of Oliver et al. (1993).

The result obtained in this study for the hornblende from Przedborowa ($335.5 \pm 5.0 \text{ Ma}$) is in agreement with the studies of Oliver et al (1993) and Lorenc (1998). Similar age (340 Ma) of the Kořmice granodiorite, determined with the Ar-Ar method, was also mentioned by Puziewicz (1992). Although one single analysis does not allow for any definite conclusion, the result obtained may suggest that the pegmatite veins cutting the Przedborowa quartz monzodiorite are of similar age as the main intrusion.

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DATOWANIE Ar-Ar HORNBLENDY Z PEGMATYTU W MONZODIORYCIE KWARCOWYM Z PRZEDBOROWEJ NA DOLNYM ŚLĄSKU — WYNIKI WSTĘPNE

Streszczenie

W pracy przedstawiono rezultat datowania próbki hornblendy wyseparowanej z żyły pegmatytu przecinającego monzodioryt kwarcowy w kamieniołomie w Przedborowej. Analizowana próbka była ręcznie wybierana pod lupą binokularną, a jej czystość sprawdzono przez obserwacje mikroskopowe preparatu proszkowego oraz analizą spektroskopową w podczerwieni. Uzyskany rezultat (335.5 ± 5.0 mln lat) jest zgodny z innymi publikowanymi danymi na temat wieku skał magmowych strefy Niemczy.



Phot. 1. Subhedral sphene crystals between hornblende (darker) and feldspars.
Plane polarized light, magn. 100×

K. DUDEK, A. WÓJTOWICZ, A. KORZENIOWSKA — Ar-Ar dating of hornblende from pegmatites in quartz monzodiorites from Przedborowa (Lower Silesia, Poland) — preliminary results