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X-RAY STUDY OF OLIVINES FROM SOME LOWER SILESIAN BASALTS

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Abstract. This paper deals with the results of X-ray examinations of olivines occurring in some Lower Silesian basalts. These have been shown to be forsterites or chrysolites. Moreover, chemical and structural features of olivine xenoliths in basalts have been investigated. On the basis of the obtained data these are supposed to originate in peridotite layer of the mantle. Some olivines have been separated gravitationally from molten basalts. Such a way of treatment of the sample did not influence the results of determination of forsterite end-member content in these minerals by means of X-ray technique used in this paper.

Olivines occur in Lower Silesian basalts as megacrysts or as main mineral component of xenoliths embedded in these rocks. The xenoliths have been examined in details by Kardymowicz (1967). Identification of chemical composition and structure of olivines of these both types is interesting as a valuable criterion for reconstruction of conditions of their origin.

Chemical composition of olivines has been determined by means of X-ray method basing on exact determination of d_{130} inter-plane spacing (Yoder, Sahama 1957).

Olivines forming xenoliths embedded in basalt occurring at Gołębnik hill in Miłoszów near Leśna display $d_{130} = 2.7708$ Å corresponding to 92,7% forsterite molecule content. For comparison, the composition of this olivine has also been computed on the ground of the formula proposed by Suturin, Suturina and Šestakov (1971)):

$$Fa = -3813.808 - 47.799a + 228.233b + 286.890c \pm 2.5\%$$

where Fa — fayalite end-member content.

The content of Fo calculated by means of this equation for the value of $a = 4.741$ Å, $b = 10.212$ Å and $c = 5.987$ Å is $92.1 \pm 2.5\%$. From the point of view of the above-mentioned authors, this method, taking into

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account all the three lattice parameters of olivine, is the most precise one. In the further part of the paper, the chemical composition of this mineral has however been determined by means of Yoder and Sahama's formula in view of its simplicity and very good concordance of the results obtained by this way with the results of determination made at the application of Suturin, Suturina and Šestakov's formula.

X-ray method of determination of chemical character of olivines is particularly useful when applied to fine-grained samples and when these minerals occur in subordinate amounts or are unevenly distributed within the rock, rendering difficult their microscopic determination. In such cases, olivines for X-ray study can be separated by means of gravitational differentiation taking place during melting of a basalt for two hours at 1350°C. The obtained material is monomineral in character. Olivines are accompanied in it only by negligible amounts of basaltic glass, which can be controlled by optical microscopy.

The results of X-ray determinations of chemical composition of olivines under consideration and the ratios of intensity of reflections $\frac{I_{020}}{I_{130}}$, $\frac{I_{020}}{I_{131}}$, $\frac{I_{020}}{I_{112}}$ are presented in Table 1. The latter values depend on the character of Mg—O bonds in olivines, determining in turn the conditions (*p*, *T*) of origin of these minerals (Kuroda 1969). It is well-known that olivines are stable within large range of temperatures and pressures. Mg—O bonds in these minerals originated under high pressure conditions are generally covalent in character whereas if the pressure is low

Table 1

Forsterite end-member content in olivines from the Lower-Silesian basalts and intensity ratio of some reflections

Olivine from basalt:	Forsterite end-member content, in per cent	$\frac{I_{020}}{I_{130}}$	$\frac{I_{020}}{I_{131}}$	$\frac{I_{020}}{I_{112}}$
Gołębnik	88.8	0.50	0.51	0.49
Gracze	86.3	0.49	0.41	0.47
Kowalskie	90.0	0.47	0.49	0.50
Krzeniów	81.2	0.48	0.44	0.38
Lutynia	92.7	0.51	0.50	0.50
Męcinka	82.8	0.43	0.41	0.41
Mikołajowice	84.2	0.40	0.49	0.44
Pielgrzymka	83.7	0.40	0.41	0.42
Stożek Perkuna	89.7	0.46	0.48	0.48
Trupień	86.0	0.43	0.51	0,48
Wilcza Góra	84.2	0.43	0.44	0.54
Wysoka Stróża	89.3	0.42	0.42	0.42

and temperature high — these are much more ionic. Olivines displaying high intensity of reflections from *020* plane, showing distinct cleavage, are typical for ultrabasic rocks formed under conditions of high pressures and temperatures, exceeding those characteristics of amphibolite facies. Olivines occurring in peridotites of Alpine type exhibit lower intensities of reflections from *020* lattice planes. The lowest value of this parameter is typical for olivines obtained synthetically under atmospheric pressure (Kuroda, Matsuhisa 1970).

As follows from the data presented in Tables 1 and 2, olivines occurring in the Lower Silesian basalts display intermediate values of intensity ratios when compared with those characteristics of these minerals from peridotites of the Alpine type and olivines synthetized under atmospheric pressure. Thermal treatment of basalts for gravitational seperation of olivines causes some change of the above intensity ratios which gradually diminish with the increase of temperature as it is in the case of olivines from xenoliths in basalt from Gołębnik hill (Tab. 2).

Olivine displaying cleavage behaves in some other way. In this case, the intensity of X-ray reflections from corresponding lattice planes decreases rapidly with the increase of temperature (Kuroda, Matsuhisa 1970). This is supposed to be connected with a change of the character of Mg—O bond from covalent to ionic. It seems, however, that the observed negligible decrease of the ratios of intensities in question with increase of temperature (Tab. 2) does not influence the results of determination of forsterite end-member contents in olivines under examination. Mg—O bonds in these minerals are rather ionic in character. Consequently, it cannot change under conditions of low pressure and merely elevated temperature and cause a decrease of cell parameters. This conclusion is supported by the result of determination of forsterite end-member content in olivines from xenoliths occurring in basalt from Gołębnik hill heated at 1800°C under atmospheric pressure for 10 hours (Fo = = 91.2%). This value is concordant (within the range of error) with those obtained for olivines from not heated xenoliths in rocks from the same locality.

The convergence of intensity ratios for olivines from xenoliths occurring in basalts and of corresponding values for these minerals from peridotite (Fo = 94.0%) is interesting (Tab. 2). The latter rock was collected from the massif exposed in the Szczęść Boże mine in Grochów, Lower Silesia. This fact seems to be of petrological importance since olivines from the above peridotite and those occurring in xenoliths within some basalts display similar character of chemical bonds. The latter conclusion is based on the comparison of intensity ratios. It should be added that the both olivines show a very similar chemical composition. It can be thus supposed that the olivine xenoliths in Lower Silesian basalts come from the upper part of peridotite layer of the Earth mantle.

The conclusions from these examinations can be summarized as follows:

1. Olivines occurring in Lower Silesian basalts are forsteritic or chrysolitic in character indicating their origin during early stage of crystallization of ultrabasic magma under conditions of moderate pressures. Com-

Table 2

Intensity ratio of some reflections of olivines from different origin

Kind of olivine	$\frac{I_{020}}{I_{130}}$	$\frac{I_{020}}{I_{131}}$	$\frac{I_{020}}{I_{112}}$
1. Olivine from xenoliths in basalt Gołębnik:			
a) unheated	0.68	0.72	0.68
b) heated at 1500°C (atmospheric pressure, 10 hours)	0.60	0.51	0.57
c) heated at 1800°C (atmospheric pressure, 10 hours)	0.60	0.49	0.51
2. Olivine from peridotite of mine Szczęść Boże:			
a) unheated	0.66	0.70	0.66
b) heated at 1500°C (atmospheric pressure, 10 hours)	0.59	0.50	0.54
c) heated at 1800°C (atmospheric pressure, 10 hours)	0.51	0.46	0.51
3. Typical olivine with cleavage*	2.268	2,158	2,34
4. Olivine from peridotites of Alpine type*	0.582	0.501	0.532
5. Olivine synthesized at atmospheric pressure*	0.276	0.233	0 233

*After Kuroda and Matsuhisa (1970).

paratively simple and precise X-ray method of Yoder and Sahama (1957) is very convenient for determining chemical composition of olivins.

2. As follows from the X-ray study, olivine xenoliths occurring in some Lower Silesian basalts come from peridotite layer of the mantle.

3. Olivine grains can be separated from molten basalt at elevated temperature by means of gravitational differentiation even when they occur in subordinate amounts and are unevenly distributed in the rock. The increased temperature does not influence the results of determinations of forsterite molecule content in olivines by means of X-ray technique used in this study.

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WYNIKI BADAŃ RENTGENOGRAFICZNYCH OLIWINÓW Z NIEKTÓRYCH BAZALTÓW DOLNOŚLĄSKICH

Streszczenie

Wykonano badania składu chemicznego oliwinów występujących w niektórych bazaltach dolnośląskich metodą rentgenograficzną. Stwierdzono, że mają one charakter forsterytu lub chryzolitu (tab. 1). Świadczy to o tworzeniu się tych minerałów w początkowym etapie krystalizacji magmy, jak też o ultrazasadowym charakterze magmy wyjściowej. Do określenia charakteru chemicznego oliwinów najbardziej przydatna jest stosunkowo prosta i dokładna metoda zaproponowana przez Yodera i Sahamę (1957). Badano również ksenolity oliwinowe występujące w niektórych skałach bazaltowych Dolnego Śląska. Ich cechy chemiczne i strukturalne (tab. 2) pozwalają twierdzić, że pochodzą one z warstwy perydotytowej płaszcza ziemskiego.

W pewnych przypadkach oliwiny wydzielano grawitacyjnie ze stopionego bazaltu. Sposób ten jest szczególnie przydatny, gdy osobniki tego minerału są drobnoziarniste, występują w niewielkiej ilości i są rozłożone w skale w sposób niejednorodny co utrudnia badania mikroskopowe. Oddziaływanie podwyższonej temperatury na oliwiny w trakcie tego procesu nie wpłynęło na wyniki oznaczeń udziału cząsteczki forsterytowej w tych minerałach stosowaną metodą rentgenograficzną.

Петр ВЫШОМИРСКИ

РЕЗУЛЬТАТЫ РЕНТГЕНОГРАФИЧЕСКОГО ИССЛЕДОВАНИЯ ОЛИВИНОВ ИЗ НЕКОТОРЫХ БАЗАЛЬТОВ НИЖНЕЙ СИЛЕЗИИ

Резюме

Рентгенографическим методом исследовался химический состав оливинов, содержащихся в некоторых базальтах Нижней Силезии. Констатировано, что они обладают характером форстерита или хризолита (табл. 1). Из этого следует, что минералы образовались в начальном этапе кристаллизации магмы и что исходная магма относилась к ультраосновному типу. Для определения химического характера оливинов наиболее пригоден сравнительно простой и точный метод, предложенный Иодером и Сахамой (1957). Кроме того, исследовались оливиновые ксенолиты, представленные в некоторых базальтах Нижней Силезии. На основании

их химических и структурных признаков (табл. 2) можно предполагать, что своим происхождением они связаны с перидотитовым слоем мантии.

В некоторых случаях оливины выделялись гравитационным путем из расплавленного базальта. Этот способ особенно рекомендуется применять, когда оливины сильно мелкозернисты, представлены в небольшом количестве и распределены в породе весьма неравномерно, что затрудняет микроскопические наблюдения. Воздействие высокой температуры во время этого процесса не повлияло на результат определения форстеритового компонента в этих минералах примененным рентгенографическим методом.