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CARBON ISOTOPES COMPOSITION OF FLUID INCLUSIONS IN ULTRAMAFIC NODULES FROM LOWER SILESIAN TERTIARY BASALTOIDS.

INTRODUCTIONS

Most of Lower Silesian Tertiary basaltoids contain ultamafic nodules. This work describes results of investigations of olivine specimens from four quarries: Księginki near Lubań, Wilcza Góra and Trupień near Złotoryja and Lutynia near Lądek-Zdrój. The spatial location of the quarries was a major reason for their selection. The rocks with accompanying nodules were described in mineralogical, petrological and geochemical details by many authors (e.g. Białowolska 1980, Kaczmarek 1993, Szynkiewicz et al. 2002).

The major goal of this work was to determine origin of fluid inclusions in olivines from ultramafic nodules. Carbon isotope analysis of CO_2 ($\delta^{13}C$ CO_2) from fluid inclusions in olivines from ultramafic nodules has been carried out due to the step-heating decrepitation method and mass spectrometric analysis. The isotope analyses have been complemented by investigations of homogenization temperatures (Th) of fluid and melt inclusions.

ANALYTHICAL PROCEDURES

The homogenization temperatures of inclusions have been reached by the quenching (Kozłowski 1981) and freezing-heating methods. The preparations were approximately 0,3-0,5 mm thick, single-side polished slices. These studies have been done at the Institute of Geochemistry, Mineralogy and Petrology (Warsaw University).

For the isotope analyses the ultramafic enclaves have been separated. Olivines have been multi-stage cleaned. First, the minerals were soaked out with H_2O_2 in order to remove organic compounds for 1 hour. After that, samples were soaked out with 0,3M HCl (1 hour), then in the mixture of CH_3OH and Cl_2CH_2 (volume

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ratio 1:1) in order to remove other forms of carbon (mainly carbonates) for 2 hours. Samples, of approximately 500 mg of clean olivines, were degassed under vacuum at 250°C. Three generations of CO_2 from decrepitation fluid inclusions in three ranges of temperatures (600°C, 1000°C and 1400°C) were obtained. CO_2 was cryogenically purified and collected to Pyrex® ampoules (ready for $\delta^{13}C$ mass analysis). Isotopic ratio was analyzed in the Mass Spectrometry Laboratory (UMCS, Lublin), using modified mass spectrometer MI-1305 with special device for nano-mole gas analysis (Hałas 1984).

RESULTS AND DISCUSSION

The enclaves represent two petrogenethic types: harzburgites (Trupień and Wilcza Góra) and lherzolites (Lutynia and Księginki). The samples show large brittle deformations (Fig.1) and contain many small inclusions placed in parallel belts crossing with the deformation structures. The primary fluid inclusions syngenetic with melt inclusions in olivines contain almost pure CO_2 but secondary inclusions of the later generations could contains mixtures of N_2, CO or CH_4 (Kozłowski 1994). It is generally accepted the $\delta^{13}C$ of mantle CO_2 varies about –6 ‰ (Nadeau et al. 1990). However the $\delta^{13}C$ values shown in Table 1 and varies from –13,82 to –46,05 ‰ and they similar those measured earlier by Kaczmarek (1993) ($\delta^{13}C$ varied from –13,49 to –39,49 ‰). The $\delta^{13}C$ values published here in the range of decrepitation temperatures from 250 to 600°C vary from –18,05 to –46,05‰ (weight average is close to –31,44 ‰). For the range of decrepitation temperatures from 600 to 1000°C $\delta^{13}C$ vary from –15,05 to –29,05 ‰ (weight average is close to –18,29 ‰) and at the melting temperature (about 1400°C) $\delta^{13}C$ vary from –13,82 to –26,32 ‰ (weight average is close to –17,49 ‰.). The results are not reproducible within the same sample (only the sample T1-d was decrepitated and analyzed twice) nor in the same quarry. It could be resulted from extreme inhomogenity of carbon system in ultamafic nodules analyzed. On the other hand, low $\delta^{13}C$ values could be resulted from following facts:

1. olivines could not contain primary inclusions with mantle carbon or these inclusions could contain other forms of carbon which were oxidized prior or during decrepitation (for example CO, CH_4),
2. the experimental procedures could influence the results: the red-ox processes during the minerals heating or CO_2 adsorption on the minerals surfaces.

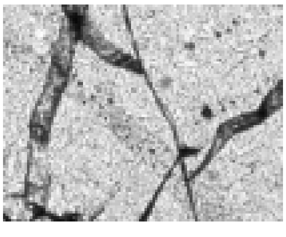

Fig.1. Photomicrograph (one polar) of olivine in harzburgite WG1-d. Highly deformed olivine crystal containing two erations of fluid inclusions (smaller and bigger). The inclusions lie in parallel belts running across the fractures in the olivine. The photomicrograph size is 400 μm across.

The obtained results of Th melt and fluid inclusions from the olivines are presented in Table 2. The Th of the primary melt inclusions from phenocrysts from the background vary from 1120 to 1200°C (±10°C). The Th of the secondary melt inclusions from crystals from the enclaves varies from 1130 to 1260°C (±10°C).

Table 1. $\delta^{13}C$ value of CO_2 from decrepitation fluid inclusions from ultramafic nodules in olivines obtained by the step-heating method.

Sample name	Quarries name	$\delta^{13}C_{PDB}$ (CO_2) fluid inclusions [‰]		
		Temp.decrep.<600 [°C]	Temp.decrep.600-1000 [°C]	Temp.decrep. (about 1400)[°C]
T1-a	Trupień	-32,55	n.a.	-16,55
T1-d/1		-28,05	-25,05	-19,55
T1-d/2		-35,32	-15,32	-26,32
WG1-c	Wilcza Góra	-18,05	-28,05	n.a.
WG1-g		-46,05	-27,05	-15,05
Lb-1	Księginki	-34,05	-29,05	-23,05
Lb-8		-26,05	-15,05	-19,05
L-3	Lutynia	-32,82	n.a.	-13,82
L-6		-30,05	-25,05	-24,05

Table 2. Physical properties of inclusions from phenocrysts from the background and the enclaves olivines.

Sample name	**Type of inclusion**	Th melt inclusion s[°C]	Th fluid inclusion s[°C]	Pressure [kbar]	Depth of crystall. [km]	Inclus. density [g/cm^3]
LB-4 (Księginki)	primary (olivine phenocrysts)	1120	+17,6	4,9	15	0,800
		1140	+15,4	5,0	15	0,825
		1140	+15,3	5,0	15	0,825
	secondary (enclave olivines)	1200	-14,0	9,4	28,5	1,015
		1200	-14,5	9,5	28,5	1,015
		1220	-14,9	9,6	28,5	1,015
WG1-d (Wilcza Góra)	secondary (enclave olivines)	1230	-23,0	10,7	33	1,055
		1250	-23,2	10,9	34	1,055
		1250	-23,2	10,9	34	1,055
		1260	-23,2	11,0	34	1,055
T1-a (Trupień)	secondary (enclave olivines)	1130	-20,2	9,5	28,5	1,035
		1190	-21,0	9,9	30	1,040
		1200	-21,0	9,9	30	1,040
L-1 (Lutynia)	primary (olivine phenocrysts)	1170	+14,0	5,7	17	0,840
		1180	+13,7	5,8	17	0,840
	secondary (enclave olivines)	1220	-20,6	10,3	31,5	1,040
		1250	-21,0	10,6	32,5	1,040
		1250	-21,1	10,6	32,5	1,040

The obtained Th values have been confirmed in other publications (Kozlowski 1994, 1995). The depth of the olivines crystallization have been obtained via the melt inclusions analysis and are in the range of 28,5 to 34 kilometers. It might be a proof of the mantle origin of the ultramafic nodules. The values of density of fluid inclusions are similar, with the exception of the Księginki quarry. The low density of fluid inclusions in this case could be caused by presence of mixtures of other gases.

CONCLUSIONS

The presented results indicate that in the olivine from nodules from Lower Silesian basaltoids do not contain primary inclusions with mantle carbon. Possibly the primary fluid inclusions decrepitated at larger depths and the mantle CO_2 consequently was released and replaced with fractionated CO_2. Low $\delta^{13}C$ values suggest, that the carbon in the CO_2 originated from reduced form of carbon (e.g. hydrocarbons or elemental carbon).

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