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CLINOPYROXENE-RICH PERIDOTITES – AN ULTRAMAFIC CUMULATE MEMBER OF THE NOWA RUDA OPHIOLITE, WEST SUDETES

Abstract: Clinopyroxene-rich peridotites, considerably serpentinized occur among troctolites and plagioclasites on the slope of the hill 559.3 m, south of Wolibórz, in the Nowa Ruda gabbroidal massif considered to belong to the circum-Góry Sowie ophiolitic sequence. Clinopyroxene-rich peridotites serpentinized to a lower degree form 6 layers within gabbroids drilled through by the borehole NR-1, situated on the slope of the above mentioned hill. Geological setting, cumulus-like texture, whole-rock chemical composition and mineral chemistry of spinels indicate that the studied rocks represent an ultramafic cumulate member of the Nowa Ruda ophiolite.

Keywords: clinopyroxene-rich peridotite, ultramafic cumulate, ophiolite, chromian spinel, aluminian chromite, chromian diopside

The gabbro-diabase massif of Nowa Ruda belongs to the Nowa Ruda ophiolite. The age of the massif was determined by means of Sm-Nd whole-rock isochrone method for 351±16 Ma by Pin et al. (1988). Dathe (1904) and Maciejewski (1957) distinguished in the massif the following types of the rocks: olivine-free gabbro, olivine gabbro, anorthite gabbro, troctolite, serpentinite (peridotite), pyroxenite and diabases. These rocks have been investigated by Maciejewski (op.cit.), Smulikowski (1973), Białowolska (1973,1979, 1999), Borkowska (1985), Pin et al. (1988) and others. According to Dathe (op. cit.), serpentinites outcrop in small area (150 x 80 m) within troctolites, on the slope of the hill 559.3 m. The same rocks were named by Maciejewski (op. cit.) olivine pyroxenites because of the

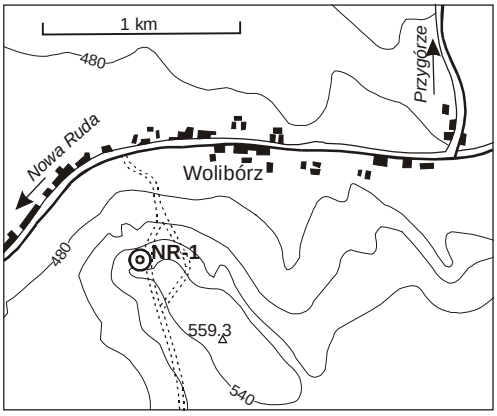

Fig.1. Location of the NR-1 borehole, near Wolibórz, according to Kowarz (1965).

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Table 1. Representative chemical composition of the Nowa Ruda peridotite and microprobe analyses of rock-forming minerals.

	rock	olivine		pyroxene			spinel	
	per. 1	ol 2	ol 3	opx 4	cpx 5	cpx 6	sp 7	sp 8
SiO_2	41.77	40.27	40.45	54.80	51.28	50.56	0.16	0.15
TiO_2	0.19	0.00	0.00	0.30	0.55	1.32	1.01	0.82
Al_2O_3	1.97	0.00	0.00	1.52	4.00	3.54	21.95	16.66
Cr_2O_3	0.77	0.07	0.00	0.30	1.65	0.88	31.98	35.42
Fe_2O_3	2.81			1.72	0.31	2.79	12.14	14.17
FeO	6.00	13.90	13.28	8.00	3.34	2.12	24.16	26.17
MnO	0.13	0.14	0.01	0.45	0.04	0.00	0.44	0.37
ZnO	0.00						1.12	0.86
NiO	0.12	0.46	0.30				0.24	0.13
MgO	31.80	45.32	46.16	31.63	15.07	15.58	6.97	5.19
CaO	6.96	0.00	0.00	0.46	23.06	22.36		
Na_2O	0.14			0.08	0.37	0.67		
K_2O	0.01			0.00	0.10	0.00		
LOI	7.53							
Total	100.20	100.16	100.20	99.26	99.77	99.82	100.17	99.94
10 cations		4 oxygens		6 oxygens			4 oxygens	
Si	3.892	1.005	1.005	1.936	1.885	1.859	0.005	0.005
Al	0.216	0.000	0.000	0.064	0.173	0.153	0.833	0.656
Ti	0.013	0.000	0.000	0.008	0.015	0.037	0.025	0.020
Cr	0.057	0.001	0.000	0.009	0.048	0.026	0.814	0.936
Fe^{3+}	0.214			0.046	0.009	0.078	0.294	0.356
Fe^{2+}	0.451	0.290	0.276	0.237	0.103	0.065	0.650	0.732
Mn	0.010	0.003	0.000	0.014	0.001	0.000	0.012	0.010
Zn							0.027	0.021
Ni	0.009	0.009	0.006				0.006	0.003
Mg	4.417	1.686	1.709	1.666	0.826	0.854	0.334	0.259
Ca	0.695	0.000	0.000	0.017	0.908	0.881		
Na	0.025			0.005	0.026	0.048		
K	0.001			0.000	0.005	0.000		
mg	0.905	0.852	0.861	0.870	0.888	0.929	0.339	0.261

presence of up to several centimetres big clinopyroxene grains. As to their chemical and modal composition, these rocks are variously serpentinized clinopyroxene-rich (cpx-rich) spinel peridotites: lherzolites with transitions to wehrlites. The rocks can be found also in the core of the borehole NR-1 drilled by the Polish Geological Institute (Fig. 1), on the slope of the hill 559.3 m, at the altitude of 530 m. In the 500 m deep drilling through troctolites dominating (about 64 vol. % of the core) over other types of gabbro and pegmatites, there have been found 6 layers of cpx-rich peridotites and five layers of troctolites with nests or lenses of peridotites included. The aim of this paper is to give the mineralogical-geochemical characteristics of the cpx-rich peridotites and to explain their origin.

The **cpx-rich peridotites** consist of the prevailing olivine and products of its serpentinization, abundant clinopyroxene, subordinate orthopyroxene, accessory

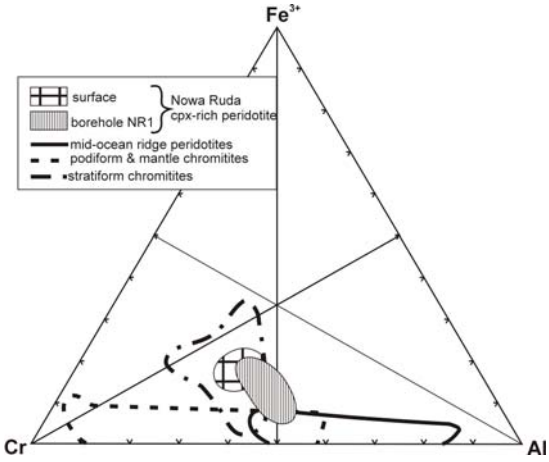

Fig. 2. Composition of chromian spinels and aluminian chromites from cpx-rich peridotites of the Nowa Nowa Ruda massif in triangle Fe^{3+}-Cr-Al.

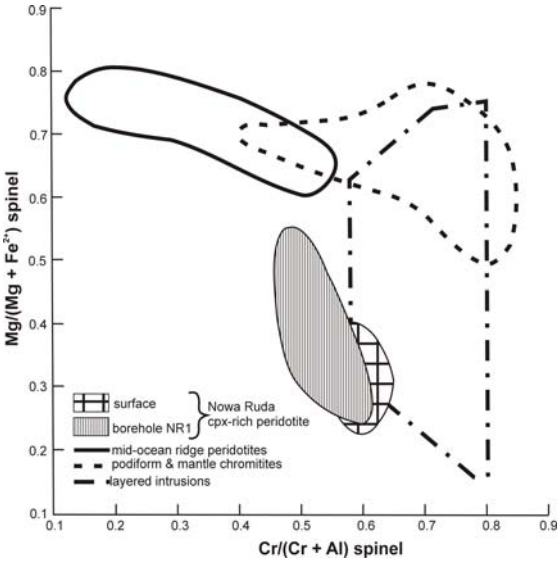

Fig. 3. Composition of spinels from the Nowa Ruda cpx-rich peridotites in diagram *mg* vs *cr* numbers.

spinel, plagioclase and apatite. **Olivine,** usually displaying a sieve texture has chrysolite composition Fo_{85-86}, similar to that of troctolite olivines, but Fe-poorer than olivine from olivine gabbro (Fo_{76}). Olivine from peridotite has considerable content of Ni (0.006-0.009 *c. pfu*). **Clinopyroxenes** usually form large grains poikilitically intergrown with rounded olivine crystals. The clinopyroxenes are diopsides Wo_{49} $En_{45-47}Fs_{4-6}$ with medium content of Al (0.153-0.173 *c. pfu*), but relatively rich in Cr (0.048-0.026, on average 0.039 *c. pfu*). Described diopsides from peridotites are, on the average, twice richer in Cr and twice poorer in Ti than diopsides and augites from troctolites and olivine gabbros of the Nowa Ruda massif. During secondary alterations, clinopyroxene grains were partly amphibolized and/or chloritized. **Orthopyroxene** from peridotites has composition of bronzite $Wo_1En_{87}Fs_{12}$ and is slightly poorer in Fe than bronzite from troctolite $Wo_1En_{85}Fs_{14}$. Scarce, often saussuritized **plagioclase** shows bytownite composition An_{72-77}. Euhedral **spinels** occur as inclusions in olivine and diopside. Spinels show the composition of aluminian chromites and chromian spinels with considerable concentrations of Zn, Ni and Ti, with ulvite content ranging from 1.7 to 5.0 mol. % (Tab. 1). Some of the spinel grains show compositional zoning with Cr increasing as well as Fe^{3+}, Ti and rarely Al decreasing rimwards. On both the discrimination diagrams for the peridotitic spinel provenance (Figs. 2 & 3), compiled mainly on the basis of data given by Irvine (1967), Kamenetsky et al. (2001), Matsukage & Kubo (2003) and Arai et al. (2004), the investigated spinels plot mostly in or close to the field of

either stratiform chromitites or spinels from layered intrusions. Moreover, the studied spinels cannot be related to the suprasubduction peridotites, as they are too rich in Ti at rather medium values of *cr* number (Kamenetsky et al. 2001). There can be also noticed some differences in mineral chemistry between spinels from highly serpentinized surface peridotites and their equivalents from less serpentinized cpx-rich peridotites from borehole NR-1, as spinels from surface peridotites are, on average, richer in Cr and show lower *mg* numbers.

On one hand, the cpx-rich peridotites in question show chemical features of slightly depleted or primitive peridotites according to their position on Cr *vs* Ti diagram (Narębski et al. 1982), while the high value of initial $epsilon_{Nd}$ = 8.5 of surrounding gabbroids points to highly depleted in LREE sources of magma (Pin et al. 1988). On the other hand, in the Coleman's CaO-Al_2O_3-MgO diagram, the studied peridotites fall into the field of ophiolitic ultramafic cumulates, beyond ultramafic tectonites (Narębski et al. 1982).

Thus, on the basis of geological setting, cumulus-like texture, whole-rock chemistry and mineral chemistry of spinels, the hypothesis can be put forward that the studied **cpx-rich peridotites represent an ultramafic cumulate member of the Nowa Ruda ophiolite**, originated in an ocean ridge environment.

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