

MOSSBAUER SPECTROSCOPY AND X-RAY STUDY OF CHRYSOLITES OF VARIOUS ORIGIN

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Chrysolite - a gem quality magnesium olivine - taken out of various deposits in the world has been studied in this work with the methods of Mossbauer spectroscopy, X-ray and microprobe analysis. Structural and chemical composition features have been examined for chrysolites of various origin including igneous chrysolite embedded in olivine basalts (Arizona, USA) and in alkali basalts (Hawaii); chrysolite from the xenolites in kimberlites (pipe Udachnaya and pipe Obnagonnaya in Yakutia) and metamorphic chrysolite from the serpentine veins in peridotites (Nuristan, Pakistan) and from veins among olivinites in hyperbasites (Kugda, East Siberia).

The microprobe analysis of chrysolites had been done with the electron microprobe Camebax SX-50. Powder X-ray diffraction was carried out with DRON-UM1 diffractometer using Co k_α radia-

tion. Data were collected in step scan mode using step of 0.05° with counting time of 2s. Metallic Si was used as internal standard for determination of the unit cell parameters.

Mossbauer spectra measurements were made using electrodynamic motor spectrometer, working in constant acceleration mode. Spectra were received on ^{57}Fe nuclei in olivines studied as absorbents of resonant γ -rays using the $^{57}\text{Co}(\text{Rh})$ source. Mossbauer spectra were approximated by combination of resonance lines, having Lorentz shape in the case of thin layer of the sample. The least square method was used for approximation. The work on spectra was done with the «Mossbauer Calculation System» computer program.

The results of microprobe and X-Ray analysis are represented in table 1.

Table 1

N	Occurrence, Locality	Colour	% Fa	Unit cell parameters, Å		
				a	b	c
1	Olivine basalts (Arizona, USA)	olive-green	11	4.727(3)	10.240(5)	5.994(3)
2	Alkali basalts (Hawaii)	olive-green	15	4.764(5)	10.206(5)	5.985 (4)
3		brown	21	4.767(5)	10.237(7)	6.0004(5)
4	Kimberlites (pipe Udachnaya, Yakutia)	light green	7	4.727(3)	10.161(3)	5.964(3)
5		olive	7.5	4.748(3)	10.204(5)	5.982(2)
6		brown	13.5	4.760(2)	10.220(4)	5.985(2)
7	Kimberlites (pipe Obnagonnaya, Yakutia)	olive-green	7.3	4.745(4)	10.201(5)	5.988(4)
8		gr.-brown	11.5	4.724(4)	10.236(5)	5.999(4)
9	Veins among olivinites in hyperbasites (Kugda, East Siberia).	green	11	4.784(3)	10.139(5)	5.929(2)
10	Serpentine veins in peridotites (Nuristan, Pakistan)	light green	6.5	4.722(4)	10.197(5)	5.974(4)

The amount of Fa in analyzed samples (22) range from 5-6 to 21 mol.%. Chrysolites from basalts have the highest amount of iron (11-21 mol.% Fa). The composition of gem quality chrysolites from Udachnaya pipe were studied more in detail for each color group (there are 8 color groups range from light green to dark brown). In seven color groups iron content is almost the same (7-8 mol.%Fa), while dark brown samples content up to 13.5mol.% Fa. There is a trend to iron content increase as the color change from light green to brown.

Impurities content (MnO , Cr_2O_3 , TiO_2) is not high in chrysolites studied except for NiO content. NiO impurity (0.20-0.55 mas.%) is detected in all samples. In the samples № 2, 3, 9 some content of MnO (0.22-0.51mas.%) and CaO (0.20-0.34 mas.%) were found.

The determined lattice parameters of chrysolite are of quite close values and have a trend to increase as iron content grows up.

The Mossbauer spectra of chrysolites, measured on ^{57}Fe nuclei at 295K, consist of a single asymmetric quadropole doublet, which represents a superposi-

tion of two doublets. These two doublets correspond for Fe^{2+} in two nonequivalent cation positions – M1 (local symmetry D_{4h}) and M2 (local symmetry C_{3v}). The value of isomer shifts, for the Fe^{2+} in D_{4h} and C_{3v} positions account to high spin configuration of Fe^{2+} (table 2). Such configuration is common for Fe^{2+} -

oxygen compounds. A big value of quadrupole splitting for Fe^{2+} in olivine is caused, for the main part, by asymmetry of electron surrounding of Fe^{2+} ions (d^6 configuration). The distribution of the Fe^{2+} between M1 and M2 sites showed no ordering it is statistic, and makes the doublets in spectra get wide.

Table 2

Mossbauer spectra parameters for Fe^{2+} in olivines

Sample	isomer shift, mm/s		Quadrupole splitting, mm/s		Position distribution, %	
	M1	M2	M1	M2	M1	M2
4	1.34	1.15	3.05	3.03	50.01	49.99
5	1.34	1.12	3.10	3.09	51.87	48.13
6	1.32	1.21	3.15	3.12	53.11	46.89
1	1.27	1.11	3.00	2.99	47.56	49.53
9	1.24	1.11	3.00	2.97	50.20	49.80
10	1.33	1.23	3.17	3.11	49.21	44.54

In Mossbauer spectra of metamorphic chrysolites (samples 9,10), besides a wide Fe^{2+} doublet, a small absorption area in the center was found (its parameters are: $\delta = 0.32 - 0.35 \text{ mm/s}$). We assume this area accounts for Fe^{3+} (d^5 configuration) occupancy of cation positions in olivine structure. The value of electrical field gradient ($\Delta = 0.55 - 0.57 \text{ mm/s}$) on Fe^{3+} nuclei is caused by the distortion of octahedral oxygen surrounding. The content of Fe^{3+} in chrysolite from Kugda (sample №9) is 2,8% out of total iron content in this sample. The content of Fe^{3+} in chrysolite from Pakistan (sample №10) is 6.3% out of total iron content.

Despite of the small Fe^{3+} doublet area, the error of Fe^{3+} content determination is less than 0.8%.

The study showed differences in chemical composition of chrysolites of various origin. Igneous chrysolites have insignificant or do not have at all any content of Fe^{3+} ions in cation positions in structure. This conforms to geological views of high temperature and high pressure olivine crystallization at reduction conditions. Metamorphic chrysolite studied formed in serpentine veins among olivinites in hyperbasites according to Mossbauer study data have a steady significant content of Fe^{3+} ions. This fact indicates that metamorphic chrysolite are formed as the results of serpentine dehydration at high oxidation conditions in not deep depth.