Vestnik Otdelenia nauk o Zemle RAN, VOL. 4, NZ9001, doi:10.2205/2012NZ_ASEMPG, 2012

"Memory" of the minerals of deep origin. The experimental determination of intrinsic oxygen fugacity

E. V. Zharkova, A. A. Kadik, V. G. Senin
V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry RAS, Moscow

kadik@geokhi.ru

The aim of this study is the experimental determination of the intrinsic oxygen fugacity of the minerals of deep origin and check up has the minerals "memory" or not.

Key words: intrinsic oxygen fugacity of the minerals, "memory", olivine, orthopyroxe, spinel

Citation: Zharkova, E. V., A. A. Kadik, V. G. Senin (2012), "Memory" of the minerals of deep origin. The experimental determination of intrinsic oxygen fugacity, *Vestn. Otd. nauk Zemle, 4*, NZ9001, doi:10.2205/2012NZ_ASEMPG

We choose for the experiments olivines (Ol) from India without inclusions and olivines (Ol ShTs 3-1), orthopyroxenes (Opx ShTs 3-1) and spinels (Spl ShTs 3-1) from xenolith of spinel lherzolith from alkaline basalts of volcano Shavarin-Tsaram (Mongolia).

The experiments were carried out on high temperature furnace based on two solid electrolyte cells. They manufactured from zirconium dioxide and stabilized by yttrium oxide in order to make the cubic structure of the electrolyte. The temperature interval is 750–1100°C. The precision of determination is ± 0.2 log fO_2.

In order to clearing up the question about the possibility of measuring crystals to keep the information of the intrinsic oxygen fugacity which is correspond with its growth were carried out the following experiments: crystals of Ol from India and Ol, Opx and Spl from xenoliths of spinel lherzoliths of Mongolia which intrinsic oxygen fugacity lies in the field between of buffer equilibrium wustite–magnetite (WM) and iron–wustite (IW) (table 1, fig. 1-4) were put into gas atmosphere which correspond with intrinsic oxygen fugacity to the buffers QFM-2 log units fO_2, QFM-3 log units fO_2, nickel–nickel oxide (Ni–NiO) and quartz–fyalite–magnetite (QFM) at the temperature 900–1100°C during 8–25 hours (table 2). Then we measured the intrinsic oxygen fugacity of the crystals again. The intrinsic oxygen fugacity begin to correspond to fO_2 buffers: QFM-2 log units fO_2, QFM-3 log units fO_2, Ni-NiO and QFM buffers (fig. 1–4).

Thus, at the result of the experiments, we revealed, that the crystals of olivine, orthopyroxenes and spinels remember the information about redox conditions at which they were formed. This is mean that the crystalls has the "memory" and the quenching isn't influence on the "memory" of the minerals.

It should be mention, that before we measured the "memory" of the minerals of deep origin we determined the intrinsic oxygen fugacity of this crystalls (table 1). We carried our the microprobe analyses as before the experiments and also after the experiments. Thus, we show that the chemical composition isn't change during the experiments.

Table 1. The values of the coefficients "A" and "B" in the empirical equation log fO_2 = A – B/T,°K for olivines, orthopyruxene and spinel

Minenal	A	B	*r	**n
Ol (India)	9.034	28888	0.998	9
Ol (India) at QFM-2 log unite fO_2	6.116	24412	0.093	8
Ol (India) at QFM-3 log unitefO_2	6.789	26759	0.982	9
ShTs 3-1 Ol	11.039	31435	0.992	11
ShTs 3-1 Ol at QFM	8.326	24480	1	5
ShTs 3-1 Ol at Ni–NiO	9.354	24920	1	7
ShTs 3-1 Opx	13.421	33982	0.996	11
ShTs 3-1 Opx at QFM	8.326	24480	1	9

ShTs 3-1 Spl	12.468	32913	0.998	11
ShTs 3-1 Spl at QFM	8.326	24380	1	8

*r – coefficient of correlation, **n – the number of experimental points.

Table 2. The values of log fO_2 for olivines, orthopyruxene and spinel at fix temperature and atmosphere

Mineral	Temperature,ºC	log fO_2	Time exposure
Ol at QFM-2 log unite.fO_2	1100	-11.664	25 hours
Ol at QFM-3 log unite fO_2	1100	-12.7	16 hours
ShTs 3-1 Ol (Ni–NiO)	900	-11.890	17 hours
ShTs 3-1 Ol (QFM)	900	-12.541	8 hours
ShTs 3-1 Opx (QFM)	900	-12.625	15 hours
ShTs 3-1 Spl (QFM)	1000	-10.904	14–16 hours
QFM*	900	-12.55	
QFM*	1000	-10.91	
Ni-NiO**	900	-11.89	

*log fO_2 (QFM) = 8.29 – 24441.9/TºK, **log fO_2 (Ni-NiO) = 9.36 –24930/TºK

Table 3. Microprobe analyses for the olivines (India) before and after the experiment of determine the "memory" of the minerals

Oxides	Ol		Ol (QFM-2)		Ol (QFM-3)	
	Before the experiment	After the experiment	Before the experiment	After the experiment	Before the experiment	After the experiment
MgO	50.51	50.34	49.83	49.8	50.48	49.59
SiO_2	40.82	40.59	40.92	41.41	40.87	41.22
TiO_2	0	0	0.03	0.02	0.01	0.01
V_2O_5	0	0	0	0.2	0	0.08
Cr_2O_3	0	0.02	0.01	0.03	0.07	0
FeO	8.38	8.68	8.84	8.68	8.48	8.46
NiO	0.45	0.16	0.45	0.57	0.48	0.44
Sum	100.16	99.79	100.08	100.39	100.37	99.1

Table 3 a. Microprobe analyses for the olivine, orthopyroxene and spinel before and after the experiment of determine the "memory" of the minerals (Shavarin-Tsaram, ShTs 3-1, Mongolia)

Oxides	Olivine		Orthopyroxene		Spynel	
	Before the experiment	After the experiment	Before the experiment	After the experiment	Before the experiment	After the experiment
SiO_2	41.01	41.2	54.55	55.61	0.051	0.028
MgO	49	48.15	31.85	30.73	21.014	21.578
CaO	0.06	0.04	0.89	0.9	-	-
TiO_2	0	0	0.16	0.19	0.15	0.127
$FeO+Fe_2O_3$	11	10.74	7.08	7	-	-
FeO	-	-	-	-	10.882	10.522
MnO	0.16	0.11	0.11	0.14	0.15	0.062
Cr_2O_3	0	0	0.3	0.35	7.202	6.675
V_2O_5	0	0.02	-	-	0.15	0.064
NiO	0.28	0.37	-	-	0.403	0.406
Na_2O	-	-	0.16	0.17	-	-
Al_2O_3			5.45	5.35	60.707	61.025
Sum	101.51	100.63	100.54	100.45	100.709	100.487
FM	11.34	11.23	11.24	11.54	-	-
Fo	88.42	88.44	-	-	-	-
Fa	11.58	11.56	-	-	-	-
Wo	-	-	1.75	1.83	-	-
En	-	-	87.2	88.84	-	-

Fs	-	-	11.05	11.33	-	-

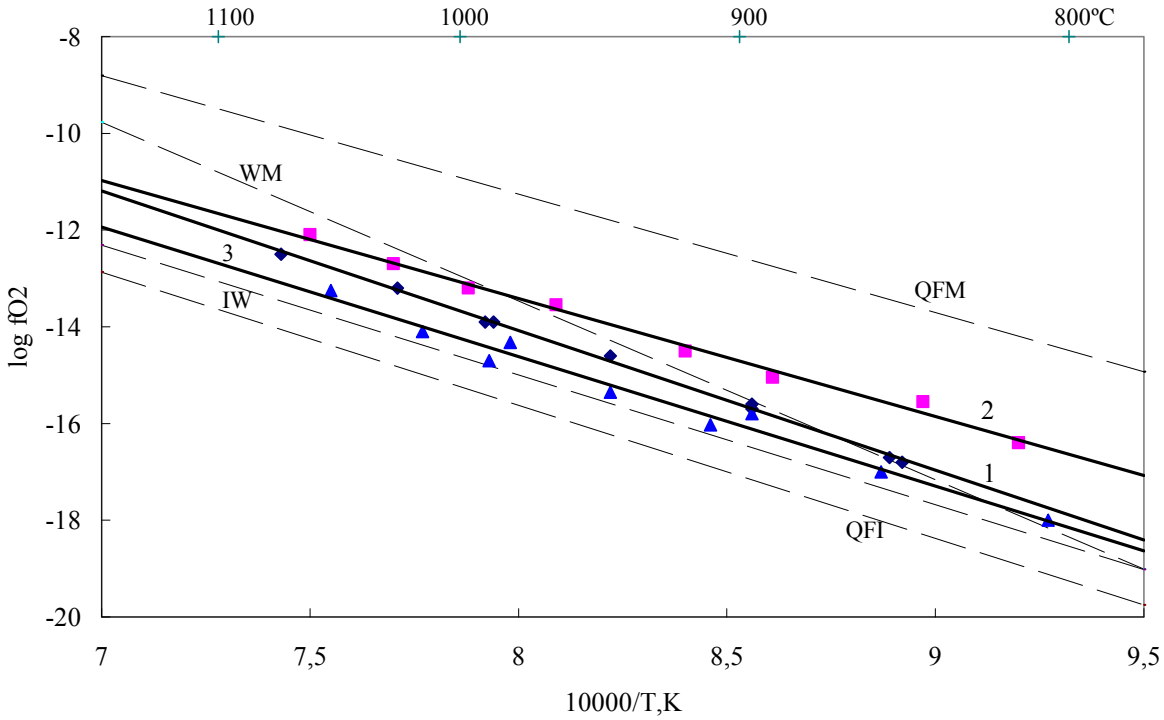

Fig. 1. The experimental determination of dependence of log $fO_2 - 10^4/T°K$ for the olivine (1), India. Control the “memory” of the olivine at QFM-2 log unite. fO_2 (2) and at QFM-3 log unite.fO_2 (3).

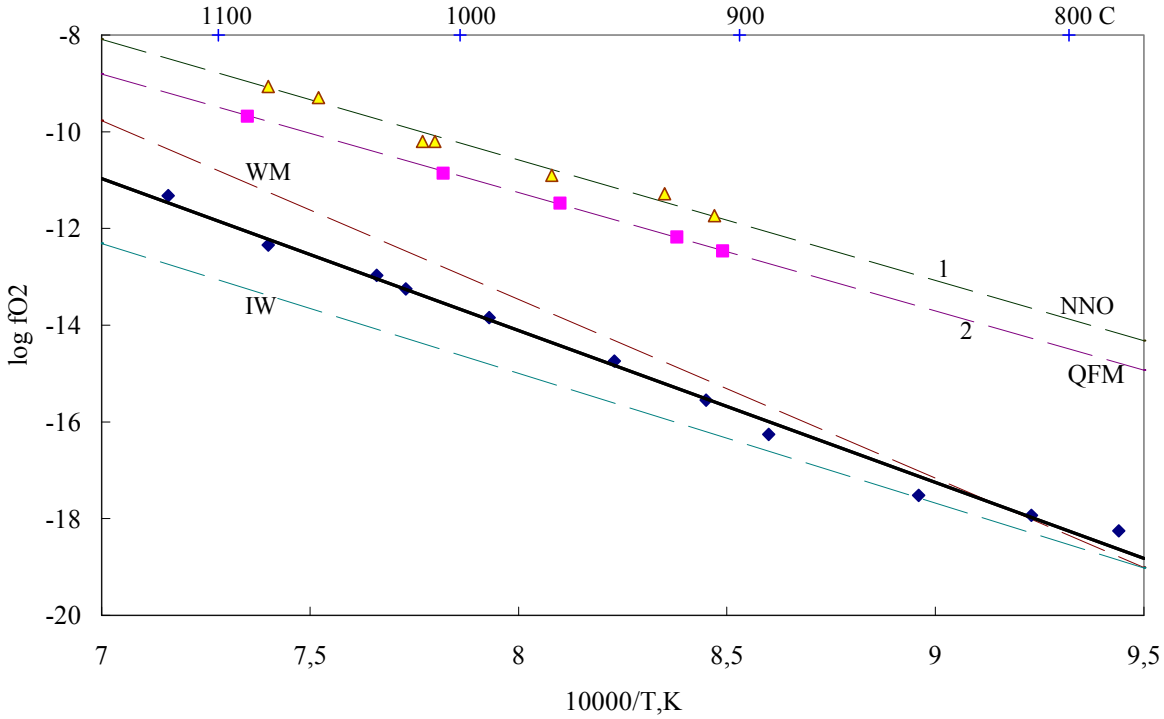

Fig. 2. The experimental determination of dependence of log $fO_2 - 10^4/T°K$ for the olivine from the spinel lherzolyth of volcano Shavarin-Tsaram (ShTs 3-1 Ol). Control the “memory” of the olivine at Ni–NiO (1) and at QFM (2).

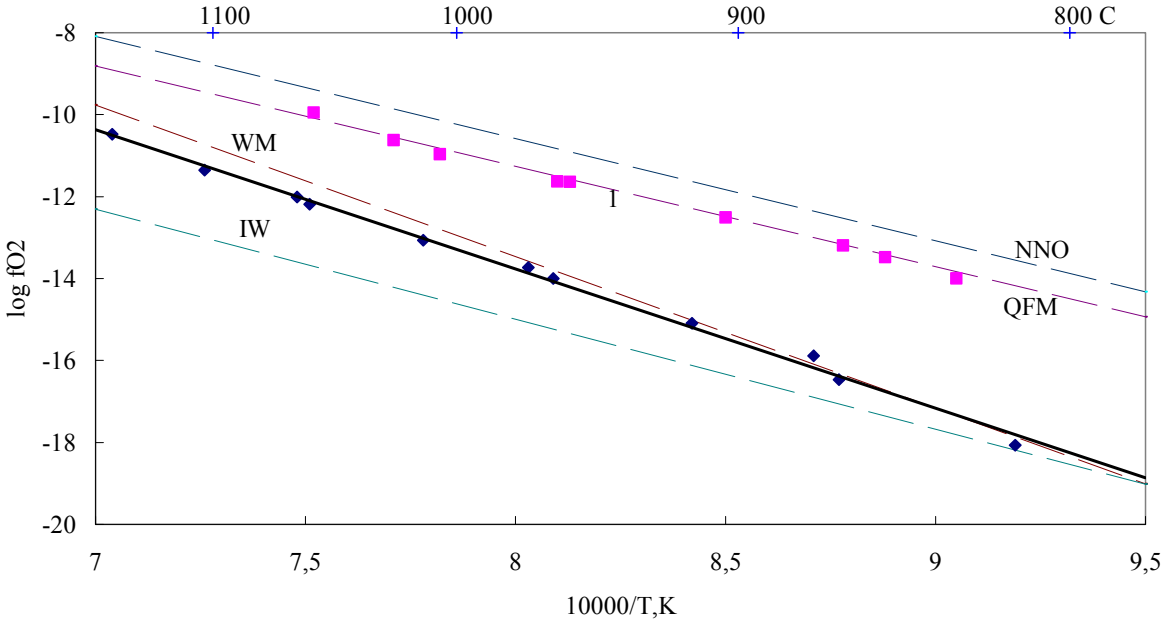

Fig. 3. The experimental determination of dependence of log fO_2 – 10^4/T°K for the orthopyroxene from the spinel lherzolyth of volcano Shavarin-Tsaram (ShTs 3-1 Opxl). Control the "memory" of the orthopyroxene at QFM (1).

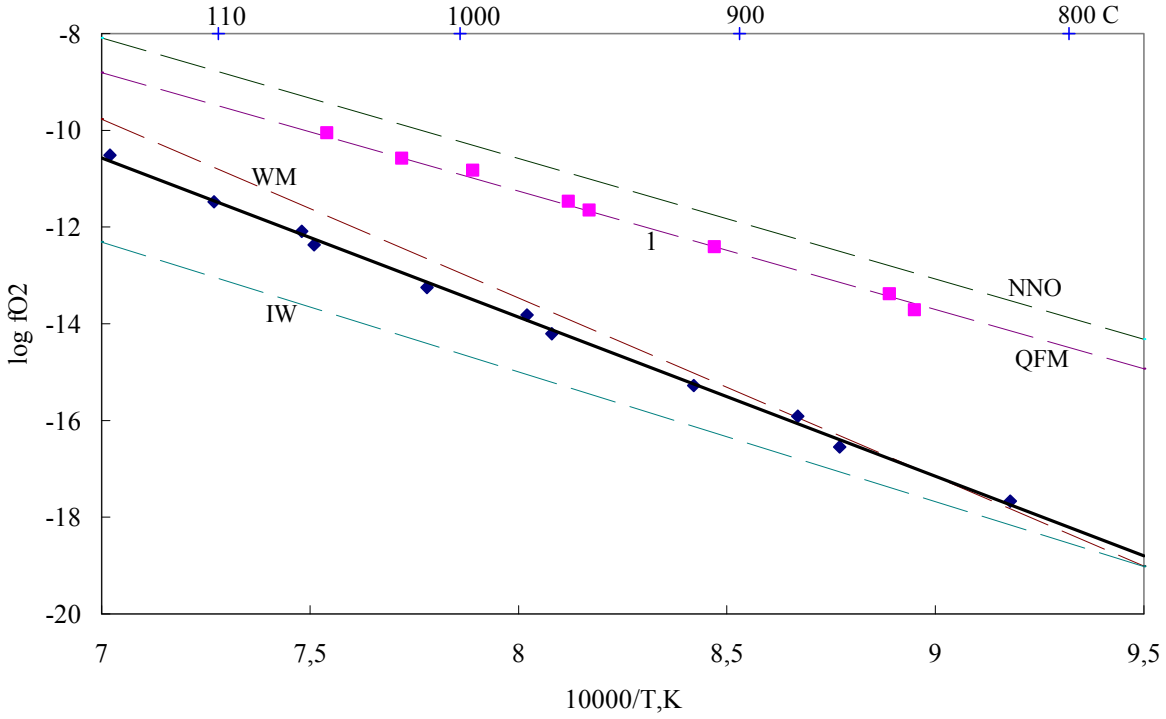

Fig. 4. The experimental determination of dependence of log fO_2 – 10^4/T°K for the spinel from the spinel lherzolyth of volcano Shavarin-Tsaram (ShTs 3-1 Spl). Control the "memory" of the olivine at Ni-NiO (1) and at QFM (2).

The investigation was carried out under support of RFFI 11-05-00926.