

Table S1. Zoned olivine composition from Bronze Age metallurgical slags of South Ural

№ п/п	Sample	Analyses place	SiO ₂	FeO	MgO	CaO	MnO	CuO	Cr ₂ O ₃	Al ₂ O ₃	Crystal chemical formula	Minals, %
1.	P25-3sh-1 Turganik	Rim	34.08	50.00	14.17	0.48	–	0.45	–	–	(Fe _{1.27} Mg _{0.64} Ca _{0.02} Cu _{0.01}) _{1.93} Si _{1.03} O ₄	Fa _{65.87} Fo _{33.31} La _{0.81}
2.		Core	34.44	44.20	20.53	0.27	–	0.39	–	–	(Fe _{1.08} Mg _{0.89} Ca _{0.01} Cu _{0.01}) _{1.99} Si _{1.01} O ₄	Fa _{54.45} Fo _{45.13} La _{0.43}
3.		Rim	32.78	55.58	10.99	0.43	–	–	0.24	–	(Fe _{1.44} Mg _{0.51} Ca _{0.01}) _{1.96} Si _{1.02} O ₄	Fa _{73.38} Fo _{25.89} La _{0.73}
4.		Core	34.36	44.40	20.58	0.25	–	–	0.19	–	(Fe _{1.08} Mg _{0.9} Ca _{0.01}) _{1.99} Si _{1.01} O ₄	Fa _{54.52} Fo _{45.09} La _{0.39}
5.		Core	38.21	22.95	38.5	0.66	–	0.33	–	–	(Mg _{1.49} Fe _{0.5} Ca _{0.02} Cu _{0.01}) _{2.01} Si _{0.99} O ₄	Fo _{74.27} Fa _{24.81} La _{0.92}
6.		Rim	32.92	52.77	13.24	0.40	–	0.33	–	–	(Fe _{1.35} Mg _{0.61} Ca _{0.01} Cu _{0.01}) _{1.98} Si _{1.01} O ₄	Fa _{68.61} Fo _{30.72} La _{0.67}
7.	P25-6sh Turganik	Core	32.49	53.70	12.99	1.20	–	–	–	–	(Fe _{1.37} Mg _{0.59} Ca _{0.04}) _{2.01} SiO ₄	Fa _{68.48} Fo _{29.56} La _{1.96}
8.		Rim	30.5	64.31	4.00	1.33	–	–	–	–	(Fe _{1.76} Mg _{0.2} Ca _{0.05}) ₂ SiO ₄	Fa _{87.91} Fo _{9.76} La _{2.33}
9.		Core	32.7	51.81	4.17	0.92	–	–	–	–	(Fe _{1.32} Mg _{0.67} Ca _{0.03}) _{2.01} Si _{0.99} O ₄	Fa _{65.37} Fo _{33.14} La _{1.49}
10.		Rim	30.88	63.51	4.77	1.75	–	–	–	–	(Fe _{1.72} Mg _{0.23} Ca _{0.06}) _{2.01} SiO ₄	Fa _{85.53} Fo _{11.45} La _{3.02}
11.	3214-718, Kamenny Ambar	Core	30.34	63.5	6.16	–	–	–	–	–	(Fe _{1.73} Mg _{0.3}) _{2.03} Si _{0.98} O ₄	Fa _{85.26} Fo _{14.74}
12.		Core	30.38	61.32	8.30	–	–	–	–	–	(Fe _{1.65} Mg _{0.4}) _{2.05} Si _{0.98} O ₄	Fa _{80.57} Fo _{19.43}
13.		Intermediate zone	31.00	64.76	3.96	0.28	–	–	–	–	(Fe _{1.77} Mg _{0.19} Ca _{0.01}) _{1.97} Si _{1.01} O ₄	Fa _{89.73} Fo _{9.78} La _{0.50}
14.		Intermediate zone	31.31	64.51	3.90	0.29	–	–	–	–	(Fe _{1.76} Mg _{0.19} Ca _{0.01}) _{1.96} Si _{1.02} O ₄	Fa _{89.81} Fo _{9.68} La _{0.52}
15.		Rim	30.69	67.69	1.30	0.33	–	–	–	–	(Fe _{1.88} Mg _{0.06} Ca _{0.01}) _{1.96} Si _{1.02} O ₄	Fa _{96.11} Fo _{3.29} La _{0.60}
16.		Core	31.36	62.61	5.08	0.29	–	–	–	–	(Fe _{1.7} Mg _{0.25} Ca _{0.01}) _{1.96} Si _{1.02} O ₄	Fa _{86.92} Fo _{12.57} La _{0.52}
17.		Rim	30.60	67.01	1.42	0.41	–	–	–	–	(Fe _{1.87} Mg _{0.07} Ca _{0.01}) _{1.96} Si _{1.02} O ₄	Fa _{95.64} Fo _{3.61} La _{0.75}
18.		Without zoning	31.34	63.81	4.56	0.26	–	–	0.22	–	(Fe _{1.73} Mg _{0.22} Ca _{0.01} Cr _{0.01}) _{1.97} Si _{1.02} O ₄	Fa _{88.04} Fo _{11.21} La _{0.46}
19.		Without zoning	32.83	66.00	1.64	0.40	–	–	–	–	(Fe _{1.78} Mg _{0.08} Ca _{0.01}) _{1.88} Si _{1.06} O ₄	Fa _{95.05} Fo _{4.21} La _{0.74}
20.		Without zoning*	32.47	60.32	6.98	0.23	–	–	–	–	(Fe _{1.6} Mg _{0.33} Ca _{0.01} Ni _{0.01}) _{1.95} Si _{1.03} O ₄	Fa _{82.07} Fo _{16.92} La _{0.40}
21.		Without zoning	32.41	59.14	7.76	0.22	–	–	–	–	(Fe _{1.57} Mg _{0.37} Ca _{0.01}) _{1.94} Si _{1.03} O ₄	Fa _{80.74} Fo _{18.88} La _{0.38}
22.		Without zoning	32.29	64.69	2.67	0.35	–	–	–	–	(Fe _{1.76} Mg _{0.13} Ca _{0.01}) _{1.9} Si _{1.05} O ₄	Fa _{92.55} Fo _{6.81} La _{0.64}
23.		Without zoning	31.80	65.08	2.83	0.29	–	–	–	–	(Fe _{1.78} Mg _{0.14} Ca _{0.01}) _{1.92} Si _{1.04} O ₄	Fa _{92.32} Fo _{7.15} La _{0.53}
24.		Without zoning	32.06	65.27	2.41	0.26	–	–	–	–	(Fe _{1.78} Mg _{0.12} Ca _{0.01}) _{1.91} Si _{1.05} O ₄	Fa _{93.38} Fo _{6.14} La _{0.48}
25.		Without zoning	31.89	64.29	3.59	0.23	–	–	–	–	(Fe _{1.75} Mg _{0.17} Ca _{0.01}) _{1.93} Si _{1.04} O ₄	Fa _{90.57} Fo _{9.01} La _{0.42}
26.	3260g/718, Kamenny Ambar	Rim	28.12	69.84	1.00	0.67	0.13	–	–	0.24	(Fe _{1.99} Mg _{0.05} Ca _{0.02}) _{2.07} Si _{0.96} Al _{0.01} O ₄	Fa _{96.18} Fo _{2.45} La _{1.18} Tf _{0.18}
27.		Core	31.00	56.33	12.30	0.19	0.18	–	–	–	(Fe _{1.47} Mg _{0.57} Ca _{0.01}) _{2.06} Si _{0.97} O ₄	Fa _{71.60} Fo _{27.86} La _{0.31} Tf _{0.23}
28.		Core	30.78	57.22	11.51	0.28	0.21	–	–	–	(Fe _{1.51} Mg _{0.54} Ca _{0.01} Mn _{0.01}) _{2.06} Si _{0.97} O ₄	Fa _{73.08} Fo _{26.19} La _{0.46} Tf _{0.27}
29.		Intermediate zone	30.27	63.26	6.03	0.44	–	–	–	–	(Fe _{1.72} Mg _{0.29} Ca _{0.02}) _{2.03} Si _{0.99} O ₄	Fa _{84.83} Fo _{14.41} La _{0.76}
30.		Rim	33.28	64.75	0.91	0.65	–	–	–	0.41	(Fe _{1.75} Mg _{0.04} Ca _{0.02}) _{1.82} Si _{1.08} Al _{0.02} O ₄	Fa _{96.35} Fo _{2.41} La _{1.24}
31.	4027/718, Kamenny Ambar	Core	35.52	40.16	24.24	0.08	–	–	–	–	(Mg _{1.03} Fe _{0.95}) _{1.98} Si _{1.01} O ₄	Fo _{51.76} Fa _{48.12} La _{0.12}
32.		Intermediate zone	35.52	49.20	15.11	0.16	–	–	–	–	(Fe _{1.22} Mg _{0.67} Ca _{0.01}) _{1.89} Si _{1.05} O ₄	Fa _{64.46} Fo _{35.28} La _{0.27}
33.		Core	35.65	40.36	23.83	0.16	–	–	–	–	(Mg _{1.01} Fe _{0.96}) _{1.97} Si _{1.05} O ₄	Fo _{51.14} Fa _{48.61} La _{0.25}
34.		Intermediate zone	35.65	50.28	13.91	0.15	–	–	–	–	(Fe _{1.25} Mg _{0.62}) _{1.88} Si _{1.06} O ₄	Fa _{66.81} Fo _{32.94} La _{0.26}
35.		Intermediate zone	33.12	55.57	11.08	0.23	–	–	–	–	(Fe _{1.44} Mg _{0.51} Ca _{0.01}) _{1.95} Si _{1.02} O ₄	Fa _{73.50} Fo _{26.11} La _{0.39}

36.		Intermediate zone	35.39	52.13	12.24	0.24	–	–	–	–	(Fe _{1.31} Mg _{0.55} Ca _{0.01}) _{1.87} Si _{1.07} O ₄	Fa _{70.21} Fo _{29.38} La _{0.41}
37.		Intermediate zone	34.83	44.29	20.74	0.13	–	–	–	–	(Fe _{1.08} Mg _{0.9}) _{1.98} Si _{1.01} O ₄	Fa _{54.40} Fo _{45.40} La _{0.20}
38.		Intermediate zone	35.96	48.89	14.88	0.27	–	–	–	–	(Fe _{1.21} Mg _{0.66} Ca _{0.01}) _{1.87} Si _{1.06} O ₄	Fa _{64.54} Fo _{35.00} La _{0.46}
39.		Core	36.05	42.19	21.76	–	–	–	–	–	(Fe _{1.01} Mg _{0.93}) _{1.94} Si _{1.03} O ₄	Fa _{52.11} Fo _{47.89}
40.	161y-10656, Ustye	Without zoning	30.57	64.39	4.05	0.37	0.47	–	–	–	(Fe _{1.77} Mg _{0.20} Ca _{0.01} Mn _{0.01}) _{1.99} SiO ₄	Fa _{88.74} Fo _{9.95} Tf _{0.66} La _{0.65}
41.		Without zoning	33.87	60.87	3.77	0.34	0.48	–	–	–	(Fe _{1.63} Mg _{0.18} Ca _{0.01} Mn _{0.01}) _{1.83} Si _{1.08} O ₄	Fa _{88.85} Fo _{9.81} Tf _{0.71} La _{0.64}
42.		Without zoning	34.62	59.41	4.52	0.26	0.53	–	–	–	(Fe _{1.57} Mg _{0.21} Ca _{0.01} Mn _{0.01}) _{1.81} Si _{1.1} O ₄	Fa _{86.94} Fo _{11.79} Tf _{0.79} La _{0.49}
43.		Without zoning	31.46	61.72	6.97	0.19	0.52	–	–	–	(Fe _{1.64} Mg _{0.33} Ca _{0.01} Mn _{0.01}) ₂ SiO ₄	Fa _{82.39} Fo _{16.58} Tf _{0.70} La _{0.32}
44.		Without zoning	30.83	63.69	4.65	0.38	0.52	–	–	–	(Fe _{1.74} Mg _{0.23} Ca _{0.01} Mn _{0.01}) _{1.99} Si _{1.01} O ₄	Fa _{87.26} Fo _{11.35} Tf _{0.72} La _{0.67}
45.		Without zoning	31.72	61.60	5.61	0.30	0.45	–	–	–	(Fe _{1.66} Mg _{0.27} Ca _{0.01} Mn _{0.01}) _{1.95} Si _{1.02} O ₄	Fa _{85.04} Fo _{13.80} Tf _{0.63} La _{0.53}
46.	w641-10-23, Sarym-Sakly	Core	35.25	37.29	26.63	0.17	–	–	0.26	–	(Mg _{1.12} Fe _{0.88} Ca _{0.01}) ₂ Si _{0.99} O ₄	Fo _{55.77} Fa _{43.83} La _{0.26}
47.		Rim	31.98	54.94	11.49	0.34	0.32	–	–	–	(Fe _{1.44} Mg _{0.54} Ca _{0.01} Mn _{0.01}) ₂ SiO ₄	Fa _{72.12} Fo _{26.88} La _{0.57} Tf _{0.43}
48.		Core	35.62	34.47	29.05	0.19	–	–	0.19	–	(Mg _{1.2} Fe _{0.8} Ca _{0.01}) _{2.01} Si _{0.99} O ₄	Fo _{59.86} Fa _{39.86} La _{0.28}
49.		Rim	31.68	56.58	10.28	0.47	–	–	0.23	–	(Fe _{1.49} Mg _{0.48} Ca _{0.02} Mn _{0.01}) _{1.99} SiO ₄	Fa _{74.94} Fo _{24.26} La _{0.8}
50.		Core	33.98	44.62	20.99	0.22	–	–	0.22	–	(Fe _{1.09} Mg _{0.91} Ca _{0.01}) _{2.01} Si _{0.99} O ₄	Fa _{54.21} Fo _{45.45} La _{0.34}
51.		Rim	31.18	60.29	7.10	0.81	0.19	–	–	–	(Fe _{1.62} Mg _{0.34} Ca _{0.03}) ₂ SiO ₄	Fa _{81.1} Fo _{17.02} La _{1.4} Tf _{0.49}
52.	P81-1sh-1 Kzyloba	Core	34.73	42.32	20.86	0.95	0.58	–	–	–	(Fe _{1.03} Mg _{0.91} Ca _{0.03} Mn _{0.01}) _{1.98} Si _{1.01} O ₄	Fa _{52.02} Fo _{45.76} La _{1.5} Tf _{0.72}
53.		Core	39.24	19.79	38.81	1.90	0.40	–	–	–	(Mg _{1.49} Fe _{0.43} Ca _{0.05} Mn _{0.01}) _{1.98} Si _{1.01} O ₄	Fo _{75.37} Fa _{21.54} La _{2.65} Tf _{0.44}
54.		Rim	35.41	38.86	24.48	0.84	0.47	–	–	–	(Mg _{1.03} Fe _{0.92} Ca _{0.03} Mn _{0.01}) _{1.99} SiO ₄	Fo _{51.94} Fa _{46.21} La _{1.28} Tf _{0.57}
55.		Core	38.35	18.73	39.29	1.98	0.53	–	–	1.78	(Mg _{1.5} Fe _{0.40} Ca _{0.05} Mn _{0.01}) _{1.96} (Si _{0.98} Al _{0.03}) _{1.01} O ₄	Fo _{76.28} Fa _{20.38} La _{2.76} Tf _{0.58}
56.		Rim	36.56	34.47	27.09	0.82	0.58	–	–	0.23	(Mg _{1.12} Fe _{0.8} Ca _{0.02} Mn _{0.01}) _{1.96} Si _{1.02} O ₄	Fo _{57.24} Fa _{40.82} La _{1.25} Tf _{0.70}

Note. Analyses were carried out using VEGA3 TESCAN SEM electron microscope (operator I.A. Blinov) in Institute of Mineralogy SU FRC MG UB RAS, dash – element is not detected. Composition also contains: * – 0.46 wt. % NiO.