

Modes of Occurrence of Critical Metal Elements (Li, REEs and Other Critical Elements) in Low-Grade Bauxite from Southern Shanxi Province, China

Table S1. Major (wt.%) and trace element (µg/g) content of Low-Grade bauxite with different particle sizes and density grades.

Sample	SiO ₂	Al ₂ O ₃	TFe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	S	P	Li	Ga	Sc	V	Cr	Co	Ni	Rb	Cs
	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01 wt. %	0.01	0.2	0.05	0.1	1	1	0.1	0.2	0.1	0.05
Y1	17.16	40.23	0.28	0.31	0.12	0.05	0.09	2.58	0.44	2190	4140	39.9	43.3	195	91	1.8	22.4	2.4	0.85
L1	—	30.32	0.36	0.30	0.17	0.04	0.07	2.47	0.31	3170	5950	40.8	37.1	231	93	1.1	32.3	1.5	0.95
L0.5	—	26.35	0.31	0.28	0.17	0.03	0.07	2.43	0.38	3030	4990	37.1	36.4	206	84	1.5	23.9	1.7	0.86
L0.25	—	25.12	0.31	0.28	0.17	0.04	0.07	2.47	0.41	3010	4750	36.3	38.2	199	82	2.2	23.9	2.4	0.85
L0.125	—	25.50	0.34	0.30	0.18	0.04	0.07	2.47	0.41	3050	4750	38.1	37.5	201	84	0.9	22.1	1.5	0.78
L0.074	—	23.04	0.43	0.28	0.18	0.04	0.06	2.36	0.41	2800	4350	33.5	35.4	190	79	1.7	23	1.5	0.72
L0.044	—	19.55	0.60	0.23	0.17	0.03	0.07	1.92	0.55	2150	3550	27.8	33.1	171	74	7.4	22.1	1.6	0.57
F1-1	—	8.05	0.16	0.10	0.15	0.01	0.04	0.52	0.47	600	1350	9.97	11.5	70	26	2.9	10.8	1.4	0.28
F1-2	—	28.81	0.36	0.30	0.17	0.04	0.07	2.58	0.35	3460	5810	39.4	37.7	221	92	1	25.6	1.5	0.93
F1-3	—	32.49	0.34	0.25	0.14	0.03	0.07	2.20	0.14	2450	6100	45.7	30.0	256	92	1	24.3	0.9	0.87
F0.5-1	—	3.87	0.04	0.05	0.15	0.01	0.01	0.18	0.51	160	560	4.22	6.1	38	13	0.7	6.9	0.6	0.1
F0.5-2	—	27.58	0.34	0.32	0.18	0.04	0.07	2.74	0.43	3570	5210	38.8	41.0	210	90	1.3	24.3	2.2	0.91
F0.5-3	—	33.91	0.34	0.25	0.14	0.03	0.07	2.21	0.15	2360	5980	50.7	31.8	258	91	1.1	25.9	1	0.89
F0.25-1	—	5.40	0.07	0.07	0.15	0.01	0.02	0.41	0.59	300	910	6.36	11.8	62	26	1	9.8	0.7	0.16
F0.25-2	—	26.07	0.33	0.32	0.18	0.04	0.07	2.71	0.45	3410	4880	38.1	41.8	208	88	2	24.3	2.2	0.88
F0.25-3	—	33.43	0.36	0.25	0.13	0.03	0.07	2.17	0.35	2420	6430	47.9	30.4	254	90	1.3	25.6	0.9	0.87
Sample	Nb	Ta	Ba	Sr	Th	U	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Y	Ho	Er	Tm
	0.1	0.05	10	0.2	0.01	0.1	0.5	0.01	0.03	0.1	0.03	0.03	0.05	0.01	0.05	0.1	0.01	0.03	0.01
Y1	52.9	3.85	40	2690	50.0	27.1	211	700.00	46.3	172.0	27.8	3.92	11.65	1.40	7.86	41.4	1.57	4.87	0.82
L1	44.8	3.33	40	4370	49.5	19.4	186.0	790.00	57.5	237	43.5	5.90	15.40	1.45	6.80	31.5	1.28	3.91	0.64
L0.5	44.7	3.41	40	4130	55.4	21.8	194.5	810.00	58.1	240	44.0	6.04	15.95	1.51	7.24	34.5	1.39	4.15	0.69

L0.25	47.1	3.45	40	4070	59.6	25.1	221	900.00	64.5	263	45.8	6.27	17.05	1.61	7.71	37.9	1.47	4.39	0.73
L0.125	47.4	3.51	40	4120	55.6	22.4	199.5	820.00	60.4	249	43.7	5.96	15.40	1.50	7.51	35.9	1.44	4.29	0.71
L0.074	44.4	3.31	40	3780	52.7	22.5	189.5	770.00	55.0	227	41.5	5.55	14.95	1.47	7.10	35.2	1.37	4.12	0.69
L0.044	34.7	2.66	40	2830	47.0	20.2	154.0	630.00	43.7	178.5	32.4	4.49	12.85	1.33	6.63	32.9	1.29	3.84	0.63
F1-1	9.3	1.09	20	702	13.65	5.9	43.9	170.5	12.30	50.1	8.66	1.19	3.56	0.39	2.14	11.4	0.42	1.26	0.20
F1-2	46.7	3.56	40	4790	51.9	19.0	185.0	800.00	59.9	249	45.5	6.17	15.95	1.50	7.11	32.4	1.34	4.03	0.68
F1-3	40.2	2.82	30	3020	23.6	12.0	76.1	343	24.7	105.5	20.5	2.89	7.95	0.79	3.82	15.4	0.74	2.33	0.41
F0.5-1	2.9	0.25	10	197.0	9.47	2.5	15.8	56.9	4.20	16.4	2.89	0.39	1.58	0.21	1.21	6.9	0.24	0.70	0.10
F0.5-2	51.2	3.92	40	4890	69.3	27.2	250	1030.00	73.8	302	54.2	7.34	18.45	1.78	8.51	41.4	1.60	4.79	0.80
F0.5-3	40.9	2.84	30	3000	26.6	12.7	95.9	420	30.0	127.5	24.2	3.30	8.94	0.87	4.22	17.5	0.81	2.49	0.43
F0.25-1	6.6	0.46	10	375	18.35	5.1	31.9	109.5	8.53	33.6	5.84	0.78	3.17	0.43	2.52	13.3	0.49	1.40	0.22
F0.25-2	52.3	3.92	40	4710	69.1	28.9	250	1010.00	73.1	298	53.5	7.07	18.55	1.78	8.59	43.3	1.64	4.89	0.82
F0.25-3	41.5	2.76	30	2970	24.7	11.8	85.1	389	27.5	116.0	22.3	3.03	8.25	0.79	3.84	16.0	0.75	2.31	0.40
sample	REE	Tl	Pb	Bi	Be	Cu	Zn	As	Mo	Cd	Ag	Ge	In	Mo	Re	Sb	Se	Te	Sn
		0.02	0.5	0.01	0.05	0.2	2	0.2	0.05	0.02	0.01	0.05	0.005	0.05	0.002	0.05	1	0.05	0.2
Y1	1195.71	0.13	54.0	2.04	4.15	12.5	4	3.8	5.19	<0.02	0.44	0.40	0.328	5.19	0.023	2.25	10	1.05	31.3
L1	1354.48	0.09	41.1	1.75	5.77	5.5	4	2.4	5.28	<0.02	0.15	0.54	0.260	5.28	0.014	1.50	6	0.86	35.6
L0.5	1389.06	0.10	39.4	1.87	5.03	9.0	5	2.9	5.27	<0.02	0.29	0.56	0.288	5.27	0.018	1.60	7	0.85	34.7
L0.25	1539.25	0.10	39.2	1.89	4.72	13.8	8	2.5	5.40	0.05	0.33	0.59	0.330	5.40	0.019	1.69	8	0.93	35.7
L0.125	1415.07	0.08	40.7	1.90	4.68	12.7	40	3.1	5.58	0.04	0.21	0.54	0.329	5.58	0.021	1.91	7	0.88	36.0
L0.074	1323.66	0.09	42.1	1.81	4.44	20.0	63	4.4	7.20	<0.02	0.22	0.50	0.358	7.20	0.019	3.32	7	0.84	37.3

L0.044	1074.55	0.11	38.0	1.64	3.28	48.1	74	3.7	7.55	0.08	0.62	0.43	0.430	7.55	0.022	2.43	8	0.72	34.0
F1-1	296.13	0.06	29.9	0.60	1.38	22.7	40	0.3	1.78	<0.02	0.14	0.18	0.138	1.78	0.009	0.55	3	0.26	40.2
F1-2	1381.54	0.09	41.6	1.84	5.84	5.2	5	2.5	5.62	<0.02	0.21	0.58	0.286	5.62	0.016	1.68	6	0.93	34.6
F1-3	592.01	0.05	34.1	1.31	5.19	1.3	4	2.4	4.08	<0.02	0.10	0.34	0.163	4.08	0.006	1.05	4	0.67	34.1
F0.5-1	101.40	0.05	4.0	0.28	0.73	21.8	33	<0.2	1.12	<0.02	0.09	0.10	0.091	1.12	0.007	0.15	2	0.20	9.8
F0.5-2	1759.59	0.11	43.6	2.08	5.39	8.2	6	3.3	5.93	<0.02	0.29	0.66	0.330	5.93	0.020	1.89	7	1.00	39.2
F0.5-3	722.11	0.05	30.4	1.29	5.26	2.0	5	2.0	4.06	<0.02	0.13	0.36	0.163	4.06	0.006	1.04	4	0.68	31.4
F0.25-1	199.99	0.07	6.1	0.40	0.93	35.7	24	0.4	1.59	<0.02	0.13	0.14	0.221	1.59	0.016	0.31	2	0.23	13.2
F0.25-2	1734.43	0.11	44.0	2.13	5.32	10.9	7	3.3	6.04	<0.02	0.35	0.69	0.360	6.04	0.022	1.98	7	0.96	40.3
F0.25-3	662.46	0.05	31.4	1.29	5.57	2.7	3	2.3	4.09	0.02	0.09	0.37	0.153	4.09	0.005	1.01	4	0.70	33.4

Note: The corresponding detection limits are shown below oxides and elements; REE represents lanthanide element (except Pm) .

Table S2. Energy spectrum data (atoms %) of SEM in figure 2 and 9.

Image	Mineral	C	Al	O	Si	Ti	Zr	S	P	K	Mg	Ga	Fe	Sr	Ce
Fig. 2e	A	Dsp	12.08	23.81	64.11	—	—	—	—	—	—	—	—	—	—
	B	Kln	—	15.26	69.05	15.68	—	—	—	—	—	—	—	—	—
	C	Ckt	27.50	10.70	53.78	8.03	—	—	—	—	—	—	—	—	—
Fig. 2f	D	Ant	—	—	72.43	—	27.57	—	—	—	—	—	—	—	—
	E	Kln	15.48	10.76	62.61	11.14	—	—	—	—	—	—	—	—	—
Fig. 2g	F	Ilt	35.00	8.10	45.45	9.35	—	—	—	1.38	—	—	0.71	—	—
Fig. 2h	G	Ant	—	—	72.67	—	27.33	—	—	—	—	—	—	—	—
	H	Zrn	—	—	66.67	16.71	—	16.63	—	—	—	—	—	—	—
Fig. 8a	A	Qz	48.98	2.82	25.39	22.81	—	—	—	—	—	—	—	—	—
	B	Ckt	16.27	12.12	62.97	8.65	—	—	—	—	—	—	—	—	—
Fig. 8b	C	Ckt	—	20.42	63.26	16.32	—	—	—	—	—	—	—	—	—
	D	Chm	—	13.84	57.93	8.94	—	—	—	—	3.99	—	15.30	—	—
Fig. 8c	E	Goy	—	18.32	62.72	4.82	—	—	1.52	5.61	—	4.23	—	2.77	—
	F	Ckt	—	22.87	62.85	14.27	—	—	—	—	—	—	—	—	—
Fig. 8d	G	Flo	29.35	9.33	55.10	5.20	—	—	—	0.93	—	—	—	—	0.09

Image		Mineral	C	Al	O	Si	Ti	Zr	S	P	K	Mg	Ga	Fe	Sr	Ce
Fig. 8e	H	Ckt	—	21.55	63.07	15.37	—	—	—	—	—	—	—	—	—	—
	I	Kln	—	17.83	63.65	18.45	—	—	—	—	—	—	—	—	—	—
Fig. 8f	J	Goy	18.55	11.11	62.39	—	—	—	0.91	4.32	—	—	—	—	2.46	0.27

Note: Dsp: Diaspore; Kln: Kaolinite; Ckt: Cookeite; Ant: Anatase; Ill: Illite; Zrn: Zircon; Qz: Quartz; Chm: Chamosite; Goy: Goyazite; Flo: Florencite.