Table S1 The natural abundances of trace elements in Continental crust, world coal and coal ash (ppm).

	Continental crust[a]	World coal[b]	World coal ash[b]
Li	18	12	66
Be	2.4	1.6	9.4
Sc	16	2.9	23
V	98	25	155
Cr	126	16	100
Mn	716	86	490
Co	24	5.1	32
Ni	56	13	76
Cu	25	16	92
Zn	65	23	140
Ga	15	5.8	33
Ge	1.4	2.2	15
As	1.7	8.3	47
Se	0.12	1.3	8.8
Rb	78	14	79
Sr	333	110	740
Y	24	8.4	51
Zr	203	36	210
Nb	19	2.7	20
Mo	1.1	2.2	14
Cd	0.1	0.22	1.2
Sn	2.3	1.1	6.4
Sb	0.3	0.92	6.3
Cs	3.4	1	6.6
Ba	584	150	940
Hf	4.9	1.2	8.3
Ta	1.1	0.28	1.7
W	1	1.1	6.9
Hg	0.04	0.1	0.75
Tl	0.52	0.63	4.9
Pb	14.8	7.8	47
Bi	0.085	0.97	5.9
Th	8.5	3.3	21
U	1.7	2.4	16
REE	144.3	60.07	352.5

[a] from Wedepohl (1995); [b] from Ketris and Yudovich (2009)

Table S2 Theabundances of trace elements in different countries coal (mg/kg).

	China	India	US	Indonesia	Australia	Russian	South Africa	Germany	Poland	Kazakhstan	Colombia	Turkey
Li	31.8	4.4	9.2	9.89	12	12	12	12	12	12	12	11
Be	2.11	0.22	1.3	0.56	1.5	1.6	2.91	1.6	1.6	1.6	1.6	1.5
Sc	4.38	1.47	3	3.11	2.9	3.46	9.7	2.9	2.9	8.2	11.1	4.1
V	35.1	8.58	17	21.98	153.15	25	63.9	25	25	25	25	52
Cr	15.4	20.4	10	7.7	59.26	16	33.2	16	16	16	16	45
Mn	49.5	86	19	95.55	90.98	86	280	86	86	86	86	81
Co	7.08	3.9	3.7	3.75	35.62	5.1	13.4	5.1	5.1	5.1	5.1	7
Ni	13.7	35.8	9	7.5	39.21	13	49.6	13	13	13	13	64
Cu	17.5	4.34	12	8.73	16.37	16	23.9	16	16	16	16	14
Zn	41.4	13.3	13	11.98	127.47	23	31.5	23	23	23	23	32
Ga	6.55	1.44	4.5	2.76	16.63	5.8	14.1	5.8	5.8	5.8	5.8	5.4
Ge	2.78	0.99	0.59	1.6	16.7	2.2	1.52	2.2	2.2	2.2	2.2	1.6
As	3.79	8.3	6.5	3.77	5.29	8.3	3.14	8.3	8.3	8.3	8.3	26
Se	2.47	1.3	1.8	0.67	0.47	1.3	1.84	1.3	1.3	1.3	1.3	1.2
Rb	9.25	3.97	0.62	3.63	13.37	14	14	14	14	14	14	19
Sr	140	62.1	90	78.5	92.54	110	138.3	110	110	110	110	170
Y	18.2	2.24	6.6	7.29	45.23	8.4	17.5	8.4	8.4	8.4	10.7	6.5
Zr	89.5	11.75	19	26.66	299.12	36	169.6	36	36	36	36	37.6
Nb	9.44	0.66	1	0.95	4.85	2.7	12.7	2.7	2.7	2.7	2.7	3.1
Mo	3.08	0.52	1.2	1.07	2.71	2.2	4.24	2.2	2.2	2.2	2.2	5.4
Cd	0.25	0.05	0.02	0.02	0.02	0.22	0.22	0.22	0.22	0.22	0.22	0.1
Sn	2.11	0.7	0.001	0.56	1.94	1.1	4.33	1.1	1.1	1.1	1.1	0.9
Sb	0.84	0.08	0.61	0.31	1.03	0.92	1.41	0.92	0.92	0.92	0.92	1.1

Cs	1.13	0.41	0.7	0.52	0.82	1	1	1	1	1	1	2.5
Ba	159	97.8	93	28.29	116.93	150	262	150	150	150	150	110
Hf	3.71	0.36	0.04	1.2	4.96	1.2	1.2	1.2	1.2	1.2	1.2	0.87
Ta	0.62	0.04	0.02	0.28	0.52	0.28	0.28	0.28	0.28	0.28	0.28	0.1
W	1.08	0.26	0.1	1.1	58.89	1.1	29.1	1.1	1.1	1.1	1.1	0.69
Hg	0.163	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.09
Tl	0.47	0.18	0.00004	0.12	0.25	0.63	0.63	0.63	0.63	0.63	0.63	0.14
Pb	15.1	1.45	5	3.13	9.38	7.8	7.5	7.8	7.8	7.8	7.8	6.8
Bi	0.79	0.06	0.01	0.07	0.03	0.97	0.87	0.97	0.97	0.97	0.97	0.14
Th	5.84	0.79	1.7	1.5	5.91	3.3	4.53	3.3	3.3	3.3	3.3	2.28
U	2.43	0.19	1.1	0.51	2.95	2.4	3.3	2.4	2.4	2.4	2.4	6.9
REE	170.5	11.44	9.57	60.1	60.28	60.1	191	60.1	60.1	60.1	435.8	18.4023

*The concentration of some trace elements in Russian, Germany, Poland,Kazakhstan and Colombia are represented by the world coal.

Table S3 The coal productions of the selected countries (million tons)

Country	China	India	US	Indonesia	Australia	Russian
Production	3683.0	765.1	685.4	548.6	485.5	441.3
Country	South Africa	Germany	Poland	Kazakhstan	Colombia	Turkey
Production	252.7	169.0	122.4	117.8	84.3	84.5

Table S4The Mining potential ratios (MPR) for trace elements in coal when compared to the global production in 2017.

	MQ (Gg)	GP (Gg)	MPR
Li	153.2	61.8*	2.48
Be	12.2	5.252	2.33
Sc	29.5	0.0005	58995.6
V	277.8	90.7*	3.06
Cr	139.3	14586.6	0.01
Mn	515.7	18311.2	0.03
Co	59.7	135.55*	0.44
Ni	137.3	2170.4*	0.06
Cu	110.9	19939.8*	0.01
Zn	272.2	12527.5	0.02
Ga	47.3	0.31	152.7
Ge	23.0	0.098	234.3
As	40.1	35.5	1.13
Se	13.7	3.33	4.11
Rb	64.2	/	/
Sr	865.0	137	6.31
Y	112.2	0.4	280.6
Zr	591.2	1420.2	0.42
Nb	44.8	81.7*	0.55
Mo	18.1	289.3	0.06
Cd	1.3	26.4	0.05
Sn	11.8	300.9	0.04
Sb	5.6	130.8	0.04
Cs	7.0	0.02#	351.9
Ba	1012.2	8080.1	0.13
Hf	18.5	0.05#	370.6
Ta	3.1	1.768*	1.74
W	41.9	86.3	0.49
Hg	1.0	2.436	0.41
Tl	2.8	0.03	93.9
Pb	76.2	5059.1	0.02
Bi	4.2	10.5	0.40
Th	31.4	31	1.01
U	15.2	69*	0.22
REE	843.2	166.7*	5.06

*- the global production in 2018; #- the production in 2016.

Table S5 Distribution of high concentrations of critical resources in coal (ppm)

Element	Suggested cut-off grade	Coal deposit	Coal	Coal ash	Source
Sc	100	Yakhlinsk	20	612	(Seredin, 2006)
		Nizhne-Bikinsk	10-30	40-110	(Seredin and Finkelman, 2008)
		Rettikhovsk	10-30	30-260	(Seredin and Finkelman, 2008)
		Kuzbass		100-200	(Nifantov, 2003)
		Minusa		95-175	(Arbuzov et al., 2003)
		Xinde	16.4		(Dai et al., 2014a)
Hf		Adaohai	10.1	2587 $(Zr,Hf)_2O_5$	(Dai et al., 2012b))
		Datanhao		1457 $(Zr,Hf)_2O_5$	(Zhao et al., 2019)
		Hailiushu		1187 $(Zr,Hf)_2O_5$	(Dai et al., 2015a)
		Huayingshan		3617 $(Zr,Hf)_2O_5$	(Dai et al., 2014b)
		Guxu		4415 $(Zr,Hf)_2O_5$	(Dai et al., 2016)
		Xinde	8.49		(Dai et al., 2014a)
		Fushui	9.18		(Dai et al., 2013)
Cs		Spetsugli	30.3		(Seredin, 2003)
		Lincang	4.9		(Qi et al., 2004)
		Fushui	7.02		(Dai et al., 2013)
REE+Y	1000	Guanbanwusu	185	1121	(Dai et al., 2012a)
		Daqingshan	180		(Dai et al., 2012b)
		Huayingshan		1423	(Dai et al., 2014b)
		Moxinpo		2487 (k2)	(Dai et al., 2017)
		Haerwusu		1404	(Dai et al., 2008)
		Heidaigou		1461	(Dai et al., 2006)
		Adaohai		976	(Dai et al., 2012b)

		Guxu		1594	(Dai et al., 2016)
		Songzao	510	1153	(Dai et al., 2007)
		Eastern Kentucky	429	4198	(Hower et al., 1999)
		Vanchinsk	342	3083	(Seredin, 2004)
Ge	300	Novikovsk	700		(Seredin, 2006)
		Spetzugli	1025		(Seredin, 2006)
		Shkotovo	1040		(Seredin, 2006)
		Lincang	1294		(Dai et al., 2015b)
		Wulangtuga	240-270		(Zhuang et al., 2006)
Ga	30	Moxingpo	27.2 (k1)	67.1 (k1)	(Dai et al., 2017)
		Guanbanwusu		77.8	(Dai et al., 2012a)
		Heidaigou		44.5	(Dai et al., 2006)
		Haerwusu		135	(Dai et al., 2008)
		Adaohai		72.9	(Dai et al., 2012b)
Sr		Guanbanwusu	703		(Dai et al., 2012a)
		Haidaigou	423		(Dai et al., 2006)
		Haerwusu	350		(Dai et al., 2008)
V	1000	Moxingpo	2962 (k1)	13098 (k1, V_2O_5)	(Dai et al., 2017)
		Guiding		7134 (V_2O_5)	(Dai et al., 2018)
		Yanshan		3677 (V_2O_5)	(Dai et al., 2018)
		Chenxi		3783 (V_2O_5)	(Dai et al., 2018)
		Yishan		3871 (V_2O_5)	(Dai et al., 2018)
		Zhigansk	830	4100	(Seredin, 2004)
		Nizhne-Bikinsk	400-500		(Seredin and Finkelman, 2008)
		Western Kentucky	10600 (max)		(Hower et al., 2000)
Se	500-800	Yutangba	3638		(Dai et al., 2018)

		Guiding	152		(Dai et al., 2018)
		Yishan	118		(Dai et al., 2018)
		Moxinpo	160		(Dai et al., 2017)
Li	2000 (Li_2O)	Guanbanwusu	175	2085 (L_2O)	(Dai et al., 2012a)
		Haerwusu	116	1281	(Dai et al., 2008)
		Krylovsk		1000-3000	(Seredin, 2004)
		Verkhne-Bikinsk		1000-3000	(Seredin, 2004)
Be		Spetsugli	100-200	500-900	(Nifantov, 2003)
		Surtaikha		573	(Nifantov, 2003)

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