

Integrative Study Assessing Space And Time Variations With Emphasis On Rare Earth Elements (REE) Distribution And Their Potential On Ashes Of A Commercial (Colombian) Coal

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Table S1 - Trace elements (ppm), enrichment patterns and anomalies for individual REE for feed coals.

	S1	S2		S3		S4		Minimum	Average	Maximum	CV (%)
	C	C1	C2	C1	C2	C1	C2				
Ba	46	129	185	100	154	158	86	46	123	185	36.3
Be	<1	<1	<1	<1	<1	<1	<1	<1	n.a.	<1	n.a.
Co	1.3	2.3	2.3	2.7	2.8	3.3	1.9	1.30	2.37	3.30	25.4
Cs	<0.1	0.6	0.5	0.7	0.4	0.8	0.5	0.4	0.6	0.8	23.0
Ga	<0.5	1.3	0.6	1.3	1.2	1.3	<0.5	<0.5	0.9	1.3	52.3
Hf	0.2	0.6	0.4	0.5	0.3	0.6	0.5	0.2	0.4	0.6	31.6
Nb	<0.1	0.9	1.1	1.4	1.1	1.3	0.8	<0.1	1.0	1.4	43.7
Rb	1.5	7.3	7.4	10	6.4	9.1	8.4	1.5	7.2	10.0	35.8
Sn	<1	<1	<1	<1	<1	<1	<1	<1	n.a.	<1	n.a.
Sr	31.4	44.5	58.8	33	45.8	45.3	26.6	26.6	40.8	58.8	25.1
Ta	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	n.a.	<0.1	n.a.
Th	0.3	1.1	0.9	1	0.8	1.1	0.8	0.3	0.9	1.1	29.8
U	0.3	0.6	0.6	0.6	0.5	0.6	0.5	0.3	0.5	0.6	19.5
V	<8	30	<8	29	25	32	<8	<8	18	32	65.4
W	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	n.a.	0.50	n.a.
Zr	6.7	20.9	16.7	18.1	17.7	21.3	15.5	6.7	16.7	21.3	27.1
La	1.5	4.4	3.4	4.2	3.5	4	3.4	1.5	3.5	4.4	25.6
Ce	2.3	6.5	5.9	7.3	6.1	7.2	6.5	2.3	6.0	7.3	26.4
Pr	0.25	0.75	0.69	0.83	0.65	0.83	0.7	0.25	0.67	0.83	27.3
Nd	1	2.9	2.9	3.1	2.6	3.3	2.4	1.0	2.6	3.3	27.3
Sm	0.21	0.53	0.64	0.67	0.53	0.63	0.57	0.21	0.54	0.67	26.7
Eu	0.05	0.13	0.11	0.16	0.15	0.16	0.13	0.05	0.13	0.16	28.1
Gd	0.19	0.62	0.61	0.58	0.58	0.73	0.49	0.19	0.54	0.73	29.2
Tb	0.03	0.09	0.1	0.1	0.09	0.12	0.08	0.03	0.09	0.12	29.9
Dy	0.22	0.65	0.58	0.61	0.58	0.71	0.44	0.22	0.54	0.71	28.1
Y	0.9	4	3.7	3.4	3.9	4.3	2.9	0.90	3.30	4.30	32.3
Ho	0.04	0.13	0.12	0.1	0.12	0.14	0.11	0.04	0.11	0.14	28.0
Er	0.14	0.38	0.39	0.35	0.35	0.49	0.3	0.14	0.34	0.49	28.8
Tm	0.01	0.06	0.05	0.05	0.05	0.06	0.04	0.01	0.05	0.06	34.8
Yb	0.12	0.35	0.3	0.29	0.3	0.42	0.25	0.12	0.29	0.42	29.5
Lu	0.01	0.05	0.05	0.04	0.04	0.06	0.04	0.01	0.04	0.06	35.2
ΣREE	6.97	21.54	19.54	21.78	19.54	23.15	18.35	6.97	18.70	23.15	26.9
REO	8.36	25.92	23.52	26.19	23.55	27.86	22.09	8.36	22.50	27.86	26.9
L/H	6.99	6.53	6.20	7.67	6.41	5.90	7.83	5.90	6.79	7.83	10.0
Critical	2.34	8.15	7.78	7.72	7.67	9.08	6.25	2.34	7.00	9.08	29.3
Uncritical	2.15	6.3	5.34	6.28	5.26	6.19	5.16	2.15	5.24	6.30	25.7
Excessive	2.48	7.09	6.42	7.78	6.61	7.88	6.94	2.48	6.46	7.88	26.3
La _N /Lu _N	1.50	0.88	0.68	1.05	0.88	0.67	0.85	0.67	0.93	1.50	28.3
La _N /Sm _N	1.08	1.26	0.81	0.95	1.00	0.96	0.90	0.81	1.00	1.26	13.4
Gd _N /Lu _N	1.47	0.96	0.95	1.12	1.12	0.94	0.95	0.94	1.07	1.47	16.7
Y _N /Ho _N	0.89	1.22	1.22	1.34	1.28	1.21	1.04	0.89	1.17	1.34	12.3
Eu _N /Eu*	1.13	1.10	0.79	1.12	1.27	1.09	1.09	0.79	1.09	1.27	12.2
Ce _N /Ce*	0.87	0.83	0.91	0.92	0.95	0.93	0.99	0.83	0.91	0.99	5.1
Gd _N /Gd*	1.09	1.26	1.08	1.02	1.18	1.15	1.05	1.02	1.12	1.26	6.8
REYdef, rel%	33.57	37.84	39.82	35.45	39.25	39.22	34.06	33.57	37.03	39.82	6.6
C _{outl}	0.94	1.15	1.21	0.99	1.16	1.15	0.90	0.90	1.07	1.21	10.7

CV, coefficient of variation; REO, REE as oxides, L/H, ratio between light REE and heavy REE; REYdef, rel%,
 $(Y+Nd+Eu+Tb+Dy+Er)/\Sigma REE$; C_{outl}, $((Nd+Eu+Tb+Dy+Er+Y)/\Sigma REE)/((Ce+Ho+Tm+Yb+Lu)/\Sigma REE)$

Table S2 - Trace elements (ppm), enrichment patterns, anomalies for individual REE for bulk coal combustion ashes.

Campaign	Sample	Ba	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Y	Ho	Er
S1	BA	794	3	16.6	6.6	13.9	5.5	11.8	92.5	1	234	0.9	11.1	4.2	207	1.3	211	33	64.3	7.71	30.5	5.34	1.24	5.22	0.86	4.74	28.8	0.99	3.11
	ECO	699	2	14.2	5.1	11.9	4.9	9.1	72.7	1	206	0.7	9	3.6	172	1	197	28.8	53.4	6.41	24.8	4.76	1.04	4.34	0.72	4.24	24.8	0.87	2.63
	ESP12	861	3	18.6	7.2	21.7	4.7	12	103	6	255	1	10.4	5.1	235	4.6	182	34.4	66	7.8	30.1	5.62	1.2	5.13	0.83	5.19	29.1	1.02	3.15
	ESP15	728	4	17.9	6.3	18.4	4.7	10.8	87.2	3	247	0.8	9.9	4.4	211	1.8	173	32.3	61.5	7.25	27.2	5.21	1.23	4.67	0.78	4.68	25.9	0.95	2.92
	ESP22	894	4	18.3	7.8	24.4	4.7	12.1	104	3	250	0.7	10.8	5.2	252	2.6	173	34.4	66.2	7.94	30.7	6	1.25	5.14	0.83	4.98	29.1	1.02	3.02
	ESP25	879	4	19.1	7.3	25.1	5.1	13.1	96	3	275	0.8	12.1	5.3	266	2.2	190	36.1	70.1	8.41	31.9	6.4	1.42	5.75	0.9	5.25	32.2	1.1	3.22
	ESP32/42	853	3	17	7.2	20.4	5.1	11.6	98.7	2	246	0.9	10.4	4.8	224	1.8	182	34.3	63.9	7.64	30	5.72	1.22	5.21	0.83	4.72	29.7	0.98	3.03
	ESP35/45	866	3	18.9	7.3	22.9	4.6	12	96.1	3	272	0.9	11	5.6	247	2.3	177	34.3	66.1	8.01	30.6	5.95	1.3	5.16	0.84	4.89	29.3	1.04	3.03
	Silo	946	3	19.9	8.3	24.5	4.9	12.6	108	3	264	0.9	11.9	6	270	2.2	185	36.8	71.6	8.54	32.2	6.05	1.4	5.5	0.89	5.26	31	1.11	3.35
S2	ECO	1053	4	20.5	4.9	11.2	5	9.4	59.5	1	387	0.7	9	3.8	173	1.1	206	28.2	54.8	6.48	25.2	5.11	1.14	4.93	0.81	4.92	30.4	0.97	3.04
	ESP12	1806	4	26.3	6.7	26.7	5.6	12.2	84	3	603	0.9	12	6.1	282	2.8	206	36.3	68	8.19	32.3	6.6	1.53	6.62	1.08	6.71	42.2	1.48	4.29
	ESP22	2336	10	34.1	7.4	47.1	5.3	14.1	98.2	5	775	0.9	12.9	8	368	4.2	206	42.7	80.5	9.86	38.7	7.54	1.87	7.93	1.24	7.73	48.2	1.67	4.87
	ESP32/42	1712	7	29	8.4	46.7	5.1	14.5	111	6	530	1	13.9	8.5	398	4.6	189	45	82.9	10.2	39.9	7.7	1.77	7.33	1.15	6.95	42	1.42	4.35
	Silo	1770	7	25.3	6.7	27.3	5.2	12.6	86.1	3	600	0.8	12.7	6	269	3.2	210	37.1	68.6	8.32	32.4	6.84	1.53	6.86	1.08	6.86	41.3	1.41	4.35
S3	BA	907	4	18.5	6.1	13.2	5.2	11.5	84.8	1	295	0.8	10.5	4.6	202	1	202	34	65.1	7.8	29.8	5.87	1.32	5.72	0.9	5.49	32.6	1.16	3.45
	ESP12	1182	4	22.7	7.6	24.4	5.2	13.2	99.5	3	377	0.8	12.4	5.9	269	2	200	37.7	71.8	8.49	32.3	6.58	1.48	6.18	0.99	6.34	37.7	1.25	3.84
	ESP22	1378	3	27.6	8	35.4	5	14.3	105	4	426	1	13.3	7.6	327	3.1	187	40.7	77.1	9.41	36.4	7.27	1.63	6.81	1.07	6.71	40.1	1.38	4.09
	ESP32	1614	7	32.1	8.7	51.4	5	16	114	7	470	1.1	14.7	10.2	424	5	188	48.2	87.8	10.7	40.6	8.04	1.9	7.5	1.16	6.93	42.2	1.45	4.38
	Silo	1152	4	22.8	7.2	26.8	5.1	12.5	94.5	3	365	0.9	11.6	6.5	276	2.6	186	37.4	71.3	8.38	32.4	6.35	1.41	6	0.94	5.85	34.4	1.2	3.74
S4	BA	905	3	20	6.3	12.9	5.6	12.1	86	<1	286	0.9	11.2	4.3	200	1.3	204	33.9	66.6	7.94	30.7	6.03	1.35	5.77	0.89	5.41	31.8	1.14	3.37
	ECO	804	5	18.2	5.6	11.1	5	10.8	76.8	<1	271	0.6	10	3.9	185	1.2	189	31.6	61	7.18	27.9	5.43	1.18	5.06	0.8	4.89	29.5	0.99	3.13
	ESP12	1053	4	21.8	7	23.3	4.7	11.9	94.3	2	326	0.9	11.2	5.5	246	1.9	181	35.4	68.1	8.03	31.3	6.27	1.36	5.66	0.91	5.26	33.8	1.18	3.63
	ESP22	1291	8	26.6	7.5	36	4.6	13.8	106	4	391	1	12.6	7.3	322	4	176	40.4	74.9	9.15	35.6	6.64	1.54	6.27	0.99	6.23	36.7	1.32	3.71
	ESP32	1582	9	32.6	8.2	48.7	4.7	14.4	113	6	449	1	14.6	9.2	392	6	184	44.9	84.8	10.2	39.9	7.89	1.81	7.34	1.12	7.14	41.1	1.43	4.35
	Silo	1095	2	23.9	7.4	25	4.8	12.8	99.6	3	346	1	12.1	5.8	265	4.6	187	37.4	72.5	8.59	33.2	6.52	1.42	6.18	0.96	5.69	35.5	1.18	3.64
Minimum		699	2	14.2	4.9	11.1	4.6	9.1	59.5	<1	206	0.6	9	3.6	172	1	173	28.2	53.4	6.41	24.8	4.76	1.04	4.34	0.72	4.24	24.8	0.87	2.63
Average		1166	4.56	22.5	7.07	26	5.01	12.4	94.8	3.08	366	0.88	11.7	5.9	267	2.74	191	36.6	69.6	8.34	32.3	6.31	1.42	5.93	0.94	5.72	34.4	1.19	3.59
Maximum		2336	10	34.1	8.7	51.4	5.6	16	114	7	775	1.1	14.7	10.2	424	6	211	48.2	87.8	10.7	40.6	8.04	1.9	7.93	1.24	7.73	48.2	1.67	4.87
CV (%)		35.2	46.4	23.6	13.5	45.4	5.71	12.3	13.5	57.8	37.7	13.4	12.9	28.8	25.8	51.3	6.02	13	11.9	12.8	12.9	13.7	16	15.8	14.2	16.3	17.2	17.1	16.1

Table S2 – Continuation.

Campaign	Sample	Tm	Yb	Lu	ΣREE	REO	L/H	Critical	Uncritical	Excessive	La _N /Lu _N	La _N /Sm _N	Gd _N /Lu _N	Y _N /Ho _N	Eu _N /Eu*	Ce _N /Ce _N *	Gd _N /Gd _N *	REYdef, rel%	C _{outl}
S1	BA	0.45	3.02	0.45	189.73	228.09	7.54	69.25	51.27	69.21	0.73	0.94	0.90	1.15	1.06	0.95	1.09	36.50	1.00
	ECO	0.37	2.38	0.38	159.94	192.28	7.48	58.23	44.31	57.40	0.76	0.92	0.89	1.13	1.02	0.93	1.06	36.41	1.01
	ESP12	0.45	2.87	0.46	193.32	232.42	7.60	69.57	52.95	70.80	0.75	0.93	0.86	1.13	1.01	0.95	1.08	35.99	0.98
	ESP15	0.42	2.75	0.43	178.19	214.17	7.65	62.71	49.43	66.05	0.75	0.94	0.84	1.08	1.11	0.95	1.05	35.19	0.95
	ESP22	0.45	3.05	0.45	194.53	233.84	7.73	69.88	53.48	71.17	0.76	0.87	0.89	1.13	1.00	0.94	1.06	35.92	0.98
	ESP25	0.48	3.12	0.5	206.85	248.76	7.59	74.89	56.66	75.30	0.72	0.86	0.89	1.16	1.06	0.95	1.10	36.20	0.99
	ESP32/42	0.44	2.99	0.46	191.14	229.81	7.65	69.50	52.87	68.77	0.75	0.91	0.88	1.20	1.01	0.93	1.09	36.36	1.01
	ESP35/45	0.43	2.96	0.46	194.37	233.67	7.78	69.96	53.42	70.99	0.75	0.87	0.87	1.11	1.04	0.94	1.06	35.99	0.99
	Silo	0.44	3.2	0.46	207.80	249.84	7.75	74.10	56.89	76.81	0.80	0.92	0.93	1.10	1.09	0.95	1.08	35.66	0.96
S2	ECO	0.45	2.9	0.44	169.79	204.38	6.55	65.51	44.72	59.56	0.64	0.84	0.87	1.24	1.03	0.95	1.09	38.58	1.10
	ESP12	0.59	3.77	0.58	220.24	265.18	6.09	88.11	57.71	74.42	0.63	0.83	0.88	1.13	1.06	0.93	1.11	40.01	1.18
	ESP22	0.66	4.34	0.65	258.46	311.12	6.23	102.61	68.03	87.82	0.66	0.86	0.95	1.14	1.13	0.92	1.16	39.70	1.17
	ESP32/42	0.59	3.98	0.6	255.82	307.62	7.11	96.12	70.21	89.49	0.75	0.89	0.95	1.17	1.08	0.91	1.12	37.57	1.07
	Silo	0.6	3.81	0.58	221.64	266.75	6.06	87.52	59.12	75.00	0.64	0.82	0.92	1.16	1.03	0.92	1.13	39.49	1.17
S3	BA	0.5	3.28	0.49	197.48	237.53	6.86	73.56	53.39	70.53	0.69	0.88	0.90	1.11	1.05	0.94	1.12	37.25	1.04
	ESP12	0.52	3.38	0.53	219.08	263.65	6.88	82.65	58.95	77.48	0.71	0.87	0.90	1.19	1.05	0.95	1.10	37.73	1.07
	ESP22	0.56	3.67	0.56	237.46	285.65	6.94	90.00	64.19	83.27	0.73	0.85	0.94	1.15	1.06	0.93	1.11	37.90	1.08
	ESP32	0.58	4.04	0.6	266.07	319.91	7.40	97.17	74.43	94.47	0.80	0.91	0.97	1.15	1.12	0.91	1.12	36.52	1.03
	Silo	0.5	3.34	0.51	213.72	257.04	7.12	78.74	58.13	76.85	0.73	0.89	0.91	1.13	1.05	0.95	1.11	36.84	1.02
S4	BA	0.48	3.28	0.49	199.15	239.49	7.03	73.52	53.64	71.99	0.69	0.85	0.91	1.10	1.06	0.96	1.13	36.92	1.02
	ECO	0.42	2.8	0.45	182.33	219.32	7.24	67.40	49.27	65.66	0.70	0.88	0.87	1.18	1.03	0.95	1.10	36.97	1.03
	ESP12	0.49	3.21	0.49	205.09	246.73	7.22	76.26	55.36	73.47	0.72	0.86	0.90	1.13	1.03	0.95	1.08	37.18	1.04
	ESP22	0.53	3.44	0.54	227.96	274.12	7.30	84.77	62.46	80.73	0.75	0.92	0.90	1.10	1.09	0.92	1.11	37.19	1.05
	ESP32	0.59	3.94	0.61	257.14	309.17	7.15	95.42	70.35	91.37	0.74	0.86	0.93	1.14	1.10	0.93	1.13	37.11	1.04
	Silo	0.53	3.36	0.51	217.18	261.27	7.24	80.41	58.69	78.08	0.73	0.87	0.94	1.19	1.03	0.95	1.12	37.02	1.03
Minimum		0.37	2.38	0.38	159.34	192.28	6.06	58.23	44.31	57.40	0.63	0.82	0.84	1.08	1.00	0.91	1.05	35.19	0.95
Average		0.5	3.32	0.51	210.58	253.27	7.17	78.31	57.20	75.07	0.72	0.88	0.90	1.14	1.06	0.94	1.10	37.13	1.04
Maximum		0.66	4.34	0.65	274.52	319.91	7.78	102.61	74.43	94.47	0.80	0.94	0.97	1.24	1.13	0.96	1.16	40.01	1.18
CV (%)		14.1	13.9	13	218.11	13.11	6.90	14.72	13.17	11.95	6.15	3.75	3.37	3.11	3.26	1.48	2.42	3.26	5.77

BA, bottom ash; ECO, economizer; ESP, Electrostatic precipitator; CV, coefficient of variations; REO, rare earth elements as oxides; L/H, ratio between light REE and heavy REE; REYdef, rel%, $(Y+Nd+Eu+Tb+Dy+Er)/\Sigma REE$; Coutl, $((Nd+Eu+Tb+Dy+Er+Y)/\Sigma REE)/((Ce+Ho+Tm+Yb+Lu)/\Sigma REE)$

Table S3 – Relative enrichments (RE) for trace elements according to Meij [39].

Campaign	Sample	Ba	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	REE
S1	BA	0.6	0.2	0.4	4.3	1.8	0.9	7.7	2.0	0.1	0.2	0.6	1.2	0.5	1.7	0.2	1.0	0.9
	ECO	0.5	0.1	0.4	3.3	1.6	0.8	6.0	1.6	0.1	0.2	0.5	1.0	0.4	1.4	0.1	1.0	0.8
	ESP12	0.6	0.2	0.5	4.7	2.8	0.8	7.9	2.2	0.4	0.3	0.7	1.1	0.6	1.9	0.6	0.9	0.9
	ESP15	0.5	0.3	0.5	4.1	2.4	0.8	7.1	1.9	0.2	0.3	0.5	1.1	0.5	1.7	0.2	0.8	0.8
	ESP22	0.6	0.3	0.5	5.1	3.2	0.8	7.9	2.3	0.2	0.3	0.5	1.2	0.6	2.1	0.3	0.8	0.9
	ESP25	0.6	0.3	0.5	4.8	3.3	0.8	8.6	2.1	0.2	0.3	0.5	1.3	0.6	2.2	0.3	0.9	1.0
	ESP32/42	0.6	0.2	0.4	4.7	2.7	0.8	7.6	2.2	0.1	0.3	0.6	1.1	0.5	1.8	0.2	0.9	0.9
	ESP35/45	0.6	0.2	0.5	4.8	3.0	0.8	7.9	2.1	0.2	0.3	0.6	1.2	0.6	2.0	0.3	0.9	0.9
	Silo	0.7	0.2	0.5	5.4	3.2	0.8	8.3	2.4	0.2	0.3	0.6	1.3	0.7	2.2	0.3	0.9	1.0
S2	ECO	0.5	0.6	0.7	0.7	0.9	0.8	0.7	0.6	0.2	0.6	1.1	0.7	0.5	0.8	0.2	0.9	0.6
	ESP12	0.9	0.6	0.9	1.0	2.2	0.9	1.0	0.9	0.5	0.9	1.4	0.9	0.8	1.3	0.6	0.9	0.8
	ESP22	1.2	1.6	1.2	1.1	3.9	0.8	1.1	1.0	0.8	1.2	1.4	1.0	1.0	1.7	0.9	0.9	1.0
	ESP32/42	0.9	1.1	1.0	1.2	3.8	0.8	1.1	1.2	0.9	0.8	1.6	1.1	1.1	1.8	1.0	0.8	1.0
	Silo	0.9	1.1	0.9	1.0	2.2	0.8	1.0	0.9	0.5	0.9	1.3	1.0	0.8	1.2	0.7	0.9	0.8
S3	BA	0.7	0.8	0.6	1.1	1.0	1.3	0.9	1.0	0.2	0.7	1.5	1.1	0.8	0.7	0.4	1.1	0.9
	ESP12	0.9	0.8	0.8	1.3	1.9	1.3	1.0	1.2	0.6	0.9	1.5	1.3	1.0	1.0	0.8	1.1	1.0
	ESP22	1.0	0.6	1.0	1.4	2.7	1.2	1.1	1.2	0.8	1.0	1.9	1.4	1.3	1.2	1.2	1.0	1.1
	ESP32	1.2	1.4	1.1	1.5	4.0	1.2	1.2	1.3	1.4	1.2	2.1	1.6	1.8	1.5	1.9	1.0	1.2
	Silo	0.9	0.8	0.8	1.3	2.1	1.2	1.0	1.1	0.6	0.9	1.7	1.2	1.1	1.0	1.0	1.0	1.0
S4	BA	0.7	0.6	0.7	0.9	1.6	1.0	1.1	0.9	0.1	0.8	1.7	1.1	0.7	1.1	0.5	1.1	0.9
	ECO	0.6	1.0	0.7	0.8	1.4	0.9	1.0	0.8	0.1	0.7	1.1	1.0	0.7	1.0	0.5	1.0	0.8
	ESP12	0.8	0.8	0.8	1.0	2.9	0.8	1.1	1.0	0.4	0.9	1.7	1.1	1.0	1.3	0.7	0.9	0.9
	ESP22	1.0	1.5	1.0	1.1	4.4	0.8	1.3	1.2	0.8	1.0	1.9	1.3	1.3	1.7	1.5	0.9	1.0
	ESP32	1.2	1.7	1.2	1.2	6.0	0.8	1.3	1.2	1.1	1.2	1.9	1.5	1.6	2.1	2.3	1.0	1.2
	Silo	0.9	0.4	0.9	1.1	3.1	0.8	1.2	1.1	0.6	0.9	1.9	1.2	1.0	1.4	1.8	1.0	1.0

BA, bottom ash; ECO, economizer; ESP, Electrostatic precipitator; REE, rare earth elements;

Table S4 - Pearson correlation coefficients for feed coals. Statistically significant relations for $\rho > 0.05$ in bold.

	C	Ash	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	SO ₃	K ₂ O	CaO	TiO ₂	Ba	Co	Cs	Hf	Nb	Rb	Sr	Th	U	Zr	LREE	MREE	HREE
C	1.00																					
Ash	-0.86	1.00																				
SiO ₂	-0.76	0.94	1.00																			
Al ₂ O ₃	-0.76	0.94	0.93	1.00																		
Fe ₂ O ₃	-0.91	0.64	0.51	0.53	1.00																	
SO ₃	-0.47	0.08	0.10	0.00	0.50	1.00																
K ₂ O	-0.65	0.89	0.88	0.99	0.41	-0.10	1.00															
CaO	-0.81	0.64	0.40	0.60	0.85	0.25	0.54	1.00														
TiO ₂	-0.73	0.81	0.81	0.89	0.46	0.32	0.89	0.56	1.00													
Ba	-0.87	0.58	0.38	0.39	0.87	0.58	0.26	0.80	0.42	1.00												
Co	-0.83	0.84	0.79	0.70	0.59	0.19	0.60	0.51	0.60	0.71	1.00											
Cs	-0.78	0.87	0.82	0.89	0.48	0.15	0.87	0.61	0.91	0.54	0.82	1.00										
Hf	-0.53	0.65	0.61	0.72	0.19	0.21	0.75	0.43	0.91	0.34	0.56	0.90	1.00									
Nb	-0.94	0.95	0.90	0.90	0.76	0.23	0.82	0.71	0.80	0.70	0.90	0.89	0.63	1.00								
Rb	-0.80	0.95	0.89	0.98	0.56	0.09	0.97	0.66	0.93	0.48	0.73	0.94	0.81	0.91	1.00							
Sr	-0.63	0.19	0.01	0.03	0.75	0.64	-0.10	0.68	0.13	0.90	0.44	0.24	0.08	0.40	0.13	1.00						
Th	-0.84	0.81	0.77	0.81	0.58	0.44	0.76	0.63	0.93	0.66	0.79	0.95	0.89	0.87	0.88	0.40	1.00					
U	-0.91	0.82	0.74	0.83	0.72	0.44	0.77	0.78	0.91	0.73	0.75	0.92	0.81	0.90	0.89	0.50	0.97	1.00				
Zr	-0.86	0.82	0.78	0.76	0.59	0.50	0.69	0.57	0.88	0.71	0.85	0.91	0.83	0.86	0.84	0.44	0.98	0.93	1.00			
LREE	-0.88	0.92	0.89	0.92	0.63	0.33	0.87	0.65	0.95	0.62	0.81	0.95	0.83	0.94	0.96	0.30	0.97	0.95	0.95	1.00		
MREE	-0.94	0.84	0.76	0.73	0.72	0.52	0.64	0.67	0.80	0.83	0.88	0.87	0.72	0.90	0.81	0.57	0.94	0.92	0.98	0.93	1.00	
HREE	-0.87	0.80	0.69	0.70	0.62	0.42	0.63	0.67	0.78	0.81	0.88	0.90	0.79	0.85	0.79	0.56	0.94	0.91	0.96	0.90	0.97	1.00

LREE, light rare earth elements (La-Sm), MREE, medium rare earth elements (Eu-Y), HREE, heavy earth elements (Ho-Lu)

Table S6 – Continuation.

Sample	Fraction	Er	Tm	Yb	Lu	ΣREE	REO	L/H	Critical	Uncritical	Excessive	EF	Recovery	La _N / Lu _N	La _N / Sm _N	Gd _N / Lu _N	Y _N / Ho _N	Eu _N / Eu*	Ce _N / Ce _N *	Gd _N / Gd _N *	REYdef, rel%	C _{out}
S1 BA (mm)	>4	3.25	0.47	3.03	0.46	195.7	235.34	7.16	72.15	52.91	70.64	0.98	19.07	0.72	0.82	0.94	1.14	1.00	0.95	1.09	36.87	1.02
	4-2	3.41	0.48	3.23	0.5	206.83	248.72	7.26	76.62	55.70	74.51	1.04	19.77	0.70	0.86	0.92	1.18	1.07	0.95	1.14	37.04	1.03
	2-1	3.31	0.49	3.17	0.5	207.22	249.30	7.31	77.13	55.84	74.25	1.04	13.46	0.71	0.85	0.91	1.13	1.06	0.94	1.10	37.22	1.04
	1-0.5	3.47	0.48	3.22	0.49	208	250.17	7.39	75.25	56.47	76.28	1.04	7.61	0.73	0.84	0.92	1.18	0.99	0.96	1.09	36.18	0.99
	0.5-0.25	3.27	0.47	3.01	0.5	201.42	242.19	7.48	73.72	54.13	73.57	1.01	6.04	0.68	0.83	0.89	1.12	1.03	0.96	1.11	36.60	1.00
	0.25-0.125	3.12	0.42	2.88	0.44	184.66	222.06	7.24	67.25	50.33	67.08	0.93	7.91	0.73	0.85	0.94	1.10	1.05	0.95	1.11	36.42	1.00
	0.125-0.090	3.13	0.45	2.83	0.44	187.45	225.34	7.24	68.52	51.25	67.68	0.94	5.69	0.73	0.81	0.97	1.08	0.99	0.95	1.12	36.55	1.01
	0.090-0.063	3.23	0.44	2.95	0.47	193.16	232.33	7.33	70.55	51.99	70.62	0.97	6.35	0.70	0.85	0.89	1.13	1.07	0.96	1.10	36.52	1.00
	<0.063	3.22	0.47	3.03	0.47	199.03	239.32	7.36	73.01	54.66	71.36	1.00	14.11	0.74	0.86	0.92	1.14	1.02	0.93	1.11	36.68	1.02
S1 Eco (µm)	> 150	2.97	0.44	2.88	0.45	188.09	226.23	7.29	69.35	50.72	68.02	1.13	23.43	0.71	0.86	0.92	1.13	1.03	0.95	1.12	36.87	1.02
	150-75	1.99	0.27	1.81	0.28	112.72	135.60	6.81	42.67	30.32	39.73	0.68	18.78	0.69	0.88	0.90	1.13	1.07	0.92	1.12	37.85	1.07
	75-45	2.96	0.41	2.66	0.43	166.51	200.28	6.85	63.56	44.59	58.36	1.00	24.96	0.65	0.83	0.86	1.16	1.03	0.93	1.08	38.17	1.09
	45-25	3.28	0.49	3.15	0.48	196.1	235.92	7.15	73.29	52.71	70.10	1.18	19.74	0.69	0.81	0.89	1.19	0.98	0.95	1.09	37.37	1.05
	<25	3.64	0.54	3.5	0.53	222.56	267.73	7.14	83.23	60.41	78.92	1.34	13.09	0.72	0.86	0.91	1.17	1.04	0.93	1.09	37.40	1.05
S1 ESP12	>75	1.85	0.26	1.73	0.27	124.04	149.14	7.87	44.36	34.07	45.61	0.64	5.22	0.81	0.88	0.99	1.12	1.04	0.95	1.13	35.76	0.97
	75-45	2.69	0.37	2.59	0.39	167.49	201.41	7.47	61.26	45.61	60.62	0.86	11.02	0.74	0.85	0.92	1.19	1.04	0.94	1.10	36.58	1.01
	45-25	3.1	0.44	2.98	0.47	202.53	243.59	7.66	73.71	55.57	73.25	1.04	38.33	0.76	0.89	0.93	1.19	1.01	0.94	1.13	36.39	1.01
	<25	3.48	0.49	3.21	0.49	217.05	260.99	7.53	79.62	59.58	77.85	1.12	45.44	0.77	0.84	0.95	1.16	1.00	0.93	1.09	36.68	1.02
	45-25 ws	2.79	0.41	2.75	0.41	179.68	216.00	7.48	65.65	49.43	64.60	0.91	5.89	0.77	0.85	0.95	1.18	1.05	0.93	1.09	36.54	1.02
	<25 ws	3.33	0.49	3.18	0.48	212.12	255.02	7.56	77.79	58.06	76.27	1.09	78.03	0.77	0.84	0.95	1.16	1.02	0.93	1.08	36.67	1.02
S1 ESP15	>75	1.65	0.23	1.49	0.24	104.16	125.26	7.38	37.69	28.82	37.65	0.56	6.04	0.77	0.90	0.95	1.09	1.05	0.93	1.10	36.18	1.00
	75-45	2.45	0.33	2.27	0.35	148.67	178.71	7.35	53.59	40.60	54.48	0.79	12.17	0.73	0.84	0.95	1.06	1.03	0.96	1.10	36.05	0.98
	45-25	3.1	0.45	3.06	0.45	194.8	234.31	7.34	71.66	53.39	69.75	1.04	33.47	0.76	0.89	0.97	1.15	1.06	0.93	1.16	36.79	1.03
	<25	3.71	0.53	3.58	0.54	231.6	278.46	7.34	84.43	63.67	83.50	1.24	48.32	0.75	0.86	0.94	1.14	1.03	0.93	1.10	36.46	1.01
	45-25 ws	3.12	0.44	2.88	0.46	185.44	222.98	7.15	68.46	50.80	66.18	0.97	8.76	0.70	0.84	0.88	1.17	1.02	0.92	1.10	36.92	1.03
	<25 ws	3.42	0.52	3.35	0.52	218.07	262.29	7.41	79.91	59.70	78.46	1.14	73.33	0.73	0.88	0.91	1.18	1.06	0.94	1.09	36.64	1.02
S1 ESP22	>75	2.06	0.29	1.96	0.3	125.58	150.96	7.26	46.36	34.86	44.36	0.59	4.80	0.74	0.88	0.93	1.11	1.04	0.91	1.13	36.92	1.05
	75-45	2.69	0.38	2.48	0.38	170.15	204.44	7.77	60.59	48.04	61.52	0.80	10.46	0.81	0.87	0.96	1.11	1.05	0.92	1.09	35.61	0.98
	45-25	3.66	0.51	3.29	0.51	222.79	267.77	7.52	80.87	61.30	80.62	1.04	37.07	0.76	0.86	0.95	1.09	1.06	0.93	1.12	36.30	1.00
	<25	3.97	0.57	3.66	0.57	243.52	292.76	7.38	88.04	66.83	88.65	1.14	47.67	0.75	0.88	0.94	1.09	1.09	0.94	1.13	36.15	0.99
S1 ESP25	>75	2.35	0.34	2.2	0.35	144.14	173.22	7.46	51.62	40.52	52.00	0.70	7.46	0.74	0.87	0.89	1.05	1.03	0.91	1.09	35.81	0.99
	75-45	2.68	0.39	2.51	0.4	164.82	198.17	7.36	60.35	44.99	59.48	0.80	11.47	0.71	0.84	0.92	1.15	1.05	0.94	1.12	36.62	1.01
	45-25	3.43	0.48	3.08	0.5	207.94	250.01	7.27	75.79	57.42	74.73	1.02	35.90	0.73	0.88	0.93	1.10	1.08	0.92	1.15	36.45	1.01
	<25	3.97	0.57	3.65	0.57	240.51	289.09	7.26	86.30	66.06	88.15	1.17	45.17	0.73	0.86	0.96	1.04	1.06	0.95	1.15	35.88	0.98
S1 ESP 32/42	>75	2.01	0.3	2.01	0.3	127.71	153.53	7.62	44.43	35.60	47.68	0.68	7.11	0.77	0.91	0.90	1.10	1.05	0.96	1.06	34.79	0.93
	75-45	2.76	0.4	2.6	0.42	173.77	208.92	7.56	62.37	47.73	63.67	0.92	14.92	0.73	0.89	0.90	1.09	1.07	0.94	1.10	35.89	0.98
	45-25	3.3	0.46	3.01	0.47	201.79	242.52	7.44	72.94	55.79	73.06	1.07	35.03	0.75	0.84	0.95	1.07	1.03	0.93	1.13	36.15	1.00
	<25	3.73	0.52	3.34	0.52	222.29	267.22	7.20	81.93	59.96	80.40	1.18	42.94	0.72	0.83	0.96	1.11	1.07	0.95	1.14	36.86	1.02

Table S6 – Continuation.

Sample	Fraction	wt. %	Ct	Ba	Be	Co	Cs	Ga	Hf	Nb	Rb	Sn	Sr	Ta	Th	U	V	W	Zr	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Y	Ho
S1 ESP 35/45	>75	10.7	18.41	709	2	15.3	5.4	20.1	3.4	9.8	75.5	2	228	0.6	9.2	4.7	196	2.2	127	28.3	53.1	6.28	24	4.7	1.06	4.24	0.68	3.92	22.7	0.87
	75-45	13.6	8.77	782	2	15.5	5.9	16.6	4.7	10.9	81.9	2	238	0.7	11	4.7	207	2	173	31.2	57.7	7.15	27.9	5.17	1.18	4.88	0.78	4.73	27.4	0.97
	45-25	23.5	4.32	797	4	16.5	6.2	16.7	5.6	11.9	86	2	251	0.8	11.9	4.8	217	2	209	33.6	66.1	8.06	30.2	6.06	1.28	5.69	0.88	5.33	31.1	1.1
	<25	50.9	2.04	1022	3	22.4	8.7	30	5.4	14.4	107	3	301	1	14.2	6.5	285	2.3	196	41.1	78.3	9.7	37.4	7.29	1.6	6.85	1.03	6.3	36	1.3
S4 BA (mm)	>4	38.9	0.08	915	4	21	6.5	13	6	13.3	87.8	<1	293	1	12.2	4.7	197	3.5	219	37.1	72.3	8.35	30.8	6.25	1.37	5.79	0.94	5.61	33.7	1.13
	4-2	19.4	0.14	1004	5	21.1	6.9	14.3	5.9	13.5	91.3	1	311	1	12.8	5.1	214	1.1	219	37.6	73.7	8.73	33.5	6.64	1.43	6.4	1.01	5.87	34.5	1.23
	2-1	10.7	0.17	1023	2	20.7	7.1	15.3	6.1	13.6	92.6	1	323	0.9	12.2	5.3	223	1.8	220	36.9	71.9	8.67	33	6.52	1.49	6.24	1.03	6.08	36.7	1.26
	1-0.5	5.09	0.19	947	1	18.7	6.5	14.9	5.4	13.8	83.5	1	292	0.9	11.5	4.7	210	1.4	206	35.9	68.5	8.36	31.9	6.25	1.36	5.97	0.93	5.54	32.6	1.16
	0.5-0.25	4.57	0.45	920	5	18.2	6	14.2	5.4	13.4	81.5	2	292	0.8	11.2	4.8	204	1.7	211	34.2	67	8.2	30.1	5.89	1.34	5.87	0.91	5.35	32.4	1.14
	0.25-0.125	6.29	0.62	869	3	18.3	5.8	12.9	5.3	12	76.3	1	274	0.8	11.1	4.6	190	1.6	189	32.9	64.5	7.92	29.2	5.86	1.28	5.55	0.89	5.34	29.5	1.12
	0.125-0.090	3.38	0.37	809	6	16.6	5.5	11.7	4.9	11.4	73.9	<1	258	0.8	10.1	4.3	178	1.2	186	31.7	61.4	7.46	28.5	5.38	1.24	5.32	0.85	5.15	28.9	1.08
	0.090-0.063	3.93	0.32	876	5	17.7	5.7	11.4	5.4	12.2	77.1	1	265	0.8	11.8	4.4	185	1.5	198	33.1	66.6	7.99	31	5.88	1.3	5.63	0.9	5.53	31.6	1.19
	<0.063	7.58	0.48	900	4	18.6	5.9	13.6	5.7	12.6	81.1	1	274	0.8	11.7	4.5	191	1.5	209	33.6	66.3	8.02	30.6	6.03	1.34	5.83	0.89	5.5	31	1.12
S4 ECO (µm)	> 150	13.5	7.76	888	4	17.9	5.7	15.5	4.6	11.6	76.1	1	291	0.8	10.5	4.7	198	1.9	170	32.3	62	7.59	28.7	5.45	1.29	5.4	0.86	5.37	29.7	1.08
	150-75	27.3	9.21	638	3	12.4	4.3	8.3	3.3	8.7	59.5	<1	205	0.6	8.1	3.2	140	1.1	136	25	49.5	6.02	22.3	4.32	0.96	4	0.65	3.88	21.6	0.81
	75-45	26.7	2.9	738	4	15.4	5.3	8.8	5.2	10.6	72.3	<1	231	0.8	11.1	3.7	163	1.5	191	29.9	59.4	7.06	26.4	5.01	1.12	4.96	0.78	4.6	25.5	0.95
	45-25	17.8	1.71	844	4	17.9	5.8	10.1	6.7	11.9	75.6	<1	261	0.8	10.8	4.4	176	1.1	241	32.5	63.2	7.7	29	5.53	1.21	5.34	0.85	5.15	29.4	1.11
	<25	12.5	2.75	1131	5	23.2	7.1	18.7	7.2	14.4	93.5	2	371	1	13	5.8	227	1.6	258	37.4	74.9	9.17	35.2	6.82	1.56	6.75	1.06	6.62	38.3	1.41
S4 ESP12	>75	8.02	27.22	456	<1	9.6	3.5	6.5	2.5	6.2	46.6	<1	147	0.5	6.2	2.7	126	1.5	94.9	18.6	36.6	4.37	16.2	3.35	0.72	3.07	0.46	2.78	15.7	0.59
	75-45	14.4	10.14	743	5	14.4	5.1	10.7	4.4	9.7	71.3	1	223	0.7	9.3	4.1	176	1.6	170	29.4	57.6	6.99	27.6	4.97	1.12	4.57	0.7	4.14	24.5	0.89
	45-25	26.1	4.84	999	3	20	6.9	19.9	5.5	12.5	88.9	2	319	0.9	11.5	5.9	241	2.6	203	34.6	68.1	8.31	31.7	6.11	1.36	5.78	0.91	5.45	32	1.18
	<25	49.6	1.62	1334	6	26.3	8.5	31.8	5.5	15.2	109	3	393	1.1	13.8	6.9	293	2.9	200	41.4	81.2	9.85	38.2	7.45	1.71	7.06	1.12	6.89	39.6	1.47
	45-25 ws	5.71	2.7	842	3	16.4	6.2	11.3	5.5	11.1	79.8	1	252	0.8	10.8	4.5	184	1.2	199	31.1	62.7	7.54	28.8	5.57	1.21	5.42	0.82	4.93	29.2	1.08
	<25 ws	71.4	5.59	1369	5	27	8.7	32.5	5.6	15.7	111	3	391	1	14.3	7.3	275	2.4	205	42.7	82.9	10.2	38.2	7.5	1.68	7.21	1.14	6.76	40	1.46
S4 ESP22	>75	4.90	53.9	492	2	9.1	3	11.6	1.9	5.4	39.4	1	147	0.4	5.4	3.4	140	2.3	68.3	16.2	30.7	3.92	14.9	2.82	0.65	2.58	0.41	2.43	14.1	0.54
	75-45	10.0	20.78	970	5	18.7	5.7	23.2	3.6	10.6	75.3	3	270	0.7	10.2	5.7	252	2.8	139	32	61.6	7.45	28.5	5.62	1.19	5	0.8	4.74	27.1	1
	45-25	28.5	5.17	1265	7	25.2	7.4	32.5	4.9	14	95.2	4	356	0.9	13.8	7.2	316	3.4	178	39.5	76.6	9.42	36	7.21	1.62	6.83	1.06	6.7	37.5	1.27
	<25	55.0	1.57	1490	8	29.6	9	39.9	5.1	15.4	109	5	413	1.1	14.9	8	340	4	187	45.3	86.9	10.9	41.8	7.89	1.84	7.76	1.18	7.39	43.8	1.44
S4 ESP32	>75	3.61	41.71	1020	5	18.4	4.4	27.9	2.9	8.6	56.5	4	276	0.6	8.6	5.5	241	4	103	26	49.6	6.16	23.8	4.59	1.03	4.38	0.67	3.99	23.4	0.88
	75-45	19.0	18.54	1342	2	25.2	6.6	38.6	4.2	12.5	84.9	5	361	0.8	12.5	8.1	346	4.7	151	38.3	72.2	8.93	34.3	6.51	1.44	6.27	0.96	5.78	32.7	1.19
	45-25	32.8	3.4	1611	5	30.4	8.4	44.2	4.9	15	101	6	430	1	15.1	9.3	378	6.1	183	45.5	86.1	10.7	41.3	7.97	1.83	7.69	1.18	7.24	42.6	1.48
	<25	46.3	1.25	1663	6	32.4	8.7	46.8	4.9	15.6	107	6	440	1	15.6	9	388	4.7	182	46.7	90.2	11.2	41.4	8.19	1.95	7.87	1.24	7.51	44.3	1.57
Minimum				410	1	8.8	3.0	6.5	1.9	5.4	39.4	1	147	0.4	5.4	2.3	111	0.8	68.3	16.2	30.7	3.92	14.9	2.82	0.65	2.58	0.41	2.43	14.1	0.54
Average				875	4	17.9	6.3	18.3	5.0	11.7	84.2	2	260	0.8	11.2	4.9	216	2.0	184.1	33.2	64.3	7.83	29.8	5.84	1.29	5.48	0.86	5.16	30.1	1.07
Maximum				1663	8	32.4	9.0	46.8	7.8	15.7	115.7	9	440	1.1	15.6	9.3	388	6.1	295.6	46.7	90.2	11.22	41.8	8.19	1.95	7.87	1.24	7.51	44.3	1.57
CV (%)				27.7	39.3	26.7	22.9	48.4	22.6	20.7	20.1	62.2	25.1	21.2	20.1	27.7	25.6	53.2	22.6	19.3	19.5	19.8	19.9	19.8	20.6	20.7	20.3	21.1	21.3	20.5

Table S6 – Continuation.

Sample	Fraction	Er	Tm	Yb	Lu	ΣREE	REO	L/H	Critical	Uncritical	Excessive	EF	Recovery	La _N / Lu _N	La _N / Sm _N	Gd _N / Lu _N	Y _N / Ho _N	Eu _N / Eu*	Ce _N / Ce _N *	Gd _N / Gd _N *	REYdef, rel%	C _{outl}
S1 ESP	>75	2.62	0.37	2.27	0.36	155.5	186.84	7.66	54.98	43.52	56.97	0.75	8.05	0.79	0.91	0.91	1.03	1.07	0.94	1.08	35.36	0.97
35/45	75-45	2.86	0.42	2.76	0.41	175.5	210.96	7.32	64.85	48.40	62.26	0.85	11.55	0.76	0.91	0.92	1.12	1.07	0.91	1.10	36.95	1.04
	45-25	3.31	0.48	3.04	0.46	196.7	236.53	7.16	72.10	53.41	71.18	0.95	22.35	0.73	0.84	0.96	1.12	1.00	0.95	1.12	36.66	1.01
	<25	3.9	0.55	3.54	0.57	235.4	282.95	7.30	86.23	64.94	84.26	1.14	58.05	0.72	0.85	0.93	1.09	1.05	0.92	1.14	36.63	1.02
S4 BA (mm)	>4	3.52	0.49	3.31	0.52	211.2	254.08	7.33	75.94	57.49	77.75	1.01	39.36	0.71	0.90	0.86	1.18	1.03	0.97	1.08	35.96	0.98
	4-2	3.67	0.55	3.54	0.57	218.9	263.28	7.08	79.98	59.37	79.59	1.05	20.32	0.66	0.86	0.87	1.11	1.01	0.96	1.12	36.53	1.00
	2-1	3.84	0.55	3.58	0.57	218.3	262.67	6.85	82.14	58.33	77.86	1.05	11.22	0.65	0.86	0.85	1.15	1.05	0.95	1.08	37.62	1.05
	1-0.5	3.56	0.5	3.26	0.52	206.3	248.05	7.10	75.89	56.48	73.94	0.99	5.03	0.69	0.87	0.89	1.11	1.02	0.93	1.12	36.78	1.03
	0.5-0.25	3.42	0.51	3.27	0.49	200.1	240.68	7.00	73.52	54.16	72.41	0.96	4.38	0.70	0.88	0.93	1.12	1.06	0.94	1.14	36.74	1.02
	0.25-0.125	3.28	0.48	3.11	0.47	191.4	230.09	7.00	69.49	52.23	69.68	0.92	5.77	0.70	0.85	0.92	1.04	1.02	0.94	1.10	36.31	1.00
	0.125-0.090	3.14	0.45	2.98	0.46	184	221.23	6.98	67.78	49.86	66.37	0.88	2.98	0.69	0.89	0.90	1.06	1.06	0.94	1.12	36.83	1.02
	0.090-0.063	3.34	0.51	3.2	0.47	198.2	238.41	7.02	73.67	52.60	71.97	0.95	3.74	0.70	0.85	0.93	1.05	1.03	0.96	1.10	37.16	1.02
	<0.063	3.46	0.48	3.26	0.5	197.9	237.96	6.93	72.79	53.48	71.66	0.95	7.20	0.67	0.84	0.90	1.09	1.05	0.95	1.14	36.78	1.02
S4 ECO (μm)	>150	3.1	0.47	3.08	0.46	186.9	224.66	6.93	69.02	50.74	67.09	1.08	14.61	0.70	0.90	0.91	1.09	1.09	0.93	1.12	36.94	1.03
	150-75	2.29	0.33	2.28	0.34	144.3	173.45	7.41	51.68	39.34	53.26	0.84	22.81	0.74	0.88	0.91	1.05	1.04	0.95	1.08	35.82	0.97
	75-45	2.83	0.41	2.65	0.42	172	206.76	7.32	61.23	46.93	63.83	1.00	26.61	0.71	0.90	0.92	1.06	1.04	0.96	1.13	35.60	0.96
	45-25	3.17	0.47	3.19	0.48	188.3	226.39	7.04	68.78	51.07	68.45	1.09	19.41	0.68	0.89	0.86	1.05	1.02	0.94	1.11	36.53	1.00
	<25	4.07	0.6	3.97	0.6	228.4	274.77	6.58	86.81	60.14	81.48	1.32	16.56	0.62	0.83	0.87	1.07	1.06	0.95	1.13	38.00	1.07
S4 ESP12	>75	1.69	0.25	1.6	0.25	106.2	127.70	7.47	37.55	29.39	39.29	0.51	4.11	0.74	0.84	0.95	1.05	1.04	0.96	1.14	35.35	0.96
	75-45	2.56	0.38	2.38	0.39	168.2	202.14	7.98	60.62	45.93	61.64	0.81	11.66	0.75	0.90	0.91	1.09	1.08	0.95	1.12	36.04	0.98
	45-25	3.5	0.52	3.24	0.51	203.3	244.41	7.12	74.92	54.80	73.55	0.98	25.56	0.68	0.86	0.88	1.07	1.05	0.95	1.11	36.86	1.02
	<25	4.27	0.61	3.91	0.62	245.4	295.05	6.93	91.79	65.76	87.81	1.18	58.67	0.67	0.84	0.88	1.06	1.08	0.95	1.11	37.41	1.05
	45-25 ws	3.08	0.46	2.9	0.44	185.3	222.79	7.16	68.04	49.63	67.58	0.84	4.78	0.71	0.85	0.95	1.07	1.02	0.96	1.15	36.73	1.01
	<25 ws	4.19	0.62	3.87	0.59	249	299.46	7.09	91.97	67.60	89.44	1.13	80.44	0.72	0.86	0.95	1.08	1.05	0.94	1.11	36.93	1.03
S4 ESP22	>75	1.51	0.22	1.46	0.22	92.66	111.35	7.38	34.00	25.52	33.14	0.39	1.93	0.74	0.87	0.91	1.03	1.09	0.91	1.09	36.69	1.03
	75-45	2.89	0.42	2.83	0.41	181.6	218.21	7.54	65.22	50.07	66.26	0.77	7.76	0.78	0.86	0.95	1.07	1.01	0.94	1.08	35.92	0.98
	45-25	3.9	0.56	3.6	0.56	232.3	279.37	6.96	86.78	62.96	82.59	0.99	28.14	0.71	0.83	0.95	1.17	1.06	0.93	1.12	37.35	1.05
	<25	4.41	0.64	3.96	0.62	265.8	319.71	7.10	100.42	71.85	93.56	1.13	62.17	0.73	0.87	0.97	1.20	1.09	0.92	1.15	37.78	1.07
S4 ESP32	>75	2.44	0.35	2.26	0.34	149.9	180.18	7.26	55.33	41.13	53.43	0.58	2.09	0.76	0.86	1.00	1.05	1.06	0.92	1.14	36.91	1.04
	75-45	3.45	0.51	3.2	0.5	216.2	259.88	7.40	78.63	60.01	77.60	0.83	15.87	0.77	0.89	0.97	1.09	1.04	0.92	1.14	36.36	1.01
	45-25	4.35	0.62	3.99	0.61	263.2	316.45	7.12	98.50	71.88	92.80	1.02	33.34	0.75	0.87	0.98	1.14	1.08	0.92	1.14	37.43	1.06
	<25	4.69	0.64	4.16	0.65	272.3	327.49	7.05	101.09	73.98	97.22	1.05	48.70	0.72	0.86	0.94	1.12	1.11	0.93	1.12	37.13	1.04
Minimum		1.51	0.22	1.46	0.22	92.66	111.35	6.58	34.00	25.52	33.14	0.39	1.93	0.62	0.81	0.85	1.03	0.98	0.91	1.06	34.79	0.93
Average		3.17	0.46	2.97	0.46	192.01	230.87	7.27	70.40	52.33	69.28	0.95	22.16	0.73	0.86	0.92	1.11	1.04	0.94	1.11	36.61	1.01
Maximum		4.69	0.64	4.16	0.65	272.29	327.49	7.98	101.09	73.98	97.22	1.34	80.44	0.81	0.91	1.00	1.20	1.11	0.97	1.16	38.17	1.09
CV (%)		21.0	21.2	20.4	20.6	19.9	19.9	3.5	20.5	19.5	19.5	19.6	87.3	5.1	2.8	3.5	4.1	2.6	1.6	2.0	1.7	2.9

BA, bottom ash; ECO, economizer; ESP, Electrostatic precipitator; CV, coefficient of variation; REO, rare earth elements as oxides; L/H, ratio between light REE and heavy REE; REYdef, rel%,
 $(Y+Nd+Eu+Tb+Dy+Er)/\Sigma REE$; C_{outl}, $((Nd+Eu+Tb+Dy+Er+Y)/\Sigma REE)/((Ce+Ho+Tm+Yb+Lu)/\Sigma REE)$

Table S7 - Trace elements (ppm), enrichment patterns, anomalies for individual REE for coal combustion ashes magnetic and non-magnetic fractions.

	S1 BA		S1 ECO		S1 ESP		S4 BA		S4 ECO		S4 ESP12		Min	Avg	Max	CV (%)
	Mag	Non-mag	Mag	Non-mag	Mag	Non-mag	Mag	Non-mag	Mag	Non-mag	Mag	Non-mag				
wt. %	5.44	94.24	11.58	87.73	4.49	94.09	5.54	94.13	13.06	85.74	5.94	93.24				
Ba	821	858	686	756	641	958	859	928	704	823	679	1112	641	819	1112	16.0
Be	4	3	4	6	5	3	2	5	3	3	5	4	2	4	6	28.5
Co	19.8	17.1	21.7	13.1	43.7	18.1	23.4	18.5	34.1	14	44.1	19.7	13.1	23.9	44.1	42.9
Cs	6.3	6.9	3.8	5.2	3.6	8.1	5.3	6.6	3.8	5.7	3.2	7.80	3.2	5.5	8.1	29.0
Ga	15.6	13.7	13.8	12	27.8	23.2	12.7	12.8	13.5	11.1	24.1	22.4	11.1	16.9	27.8	32.7
Hf	5.4	5.9	3.4	6.2	3	5.4	5.1	5.8	3.6	5	3	5.4	3.0	4.8	6.2	23.6
Nb	12.1	12.5	8.4	10.5	8.7	13.5	11.7	12.9	9.4	11.3	8.7	13.2	8.4	11.1	13.5	16.2
Rb	86.7	93.3	51.6	76.3	48.1	104.5	73.4	84	54.5	76.7	45.8	98.1	45.8	74.4	104.5	26.0
Sn	1	<1	1	1	4	4	1	<1	1	<1	3	2	<1	2	4	77.6
Sr	248.6	242.1	214.1	211.5	216.3	257.6	269.9	282.5	245.3	250.6	229.8	320.0	211.5	249.0	320.0	12.0
Ta	0.8	0.8	0.7	0.8	0.6	1	0.8	0.9	0.7	0.7	0.6	0.90	0.6	0.8	1.0	15.0
Th	12.5	11.7	8.8	10	9.4	12.7	11.5	11.9	9.3	10.4	8.6	12.60	8.6	10.8	12.7	13.7
U	4.8	4.7	4.9	3.9	8.5	5.6	4.7	4.8	5	3.9	7.6	6.1	3.9	5.4	8.5	25.0
V	228	204	236	159	420	229	205	192	229	166	372	239	159	240	420	31.2
W	2.9	1.2	1.8	1.5	5.1	1.7	1.7	1.1	1.9	1	2.7	1.6	1	2.0	5.1	53.6
Zr	195.5	215.4	128.3	227	111.3	190.7	183.8	208.6	135.9	184.5	113.5	192.2	111.3	173.9	227	22.4
La	34.7	34.7	27.9	29.4	27.9	37	32.5	35.6	28.3	30.5	26.9	37.6	26.9	31.9	37.6	11.7
Ce	68.2	69.5	54.8	57.3	54.8	72.9	64.2	68.5	55.4	60.7	51.7	72.7	51.7	62.6	72.9	11.8
Pr	8.24	8.25	6.76	7	6.68	8.79	7.83	8.38	6.7	7.32	6.37	8.83	6.37	7.60	8.83	11.2
Nd	31.1	32	26	26.1	26.1	33.5	31	31.4	26	27.9	25.3	34	25.3	29.2	34	10.7
Sm	6.2	6.09	5.28	5.16	5.24	6.67	5.8	6.15	5.37	5.37	5.12	6.65	5.12	5.76	6.67	9.6
Eu	1.4	1.33	1.23	1.14	1.28	1.4	1.32	1.38	1.2	1.16	1.23	1.43	1.14	1.29	1.43	7.4
Gd	5.78	5.86	5.39	4.86	5.35	6.07	5.65	5.83	5.37	5.03	5.15	6.2	4.86	5.55	6.20	7.2
Tb	0.94	0.89	0.87	0.78	0.83	0.94	0.91	0.94	0.83	0.79	0.82	0.98	0.78	0.88	0.98	7.2
Dy	5.55	5.38	5.15	4.76	4.92	5.52	5.45	5.63	5.13	4.8	4.97	5.8	4.76	5.26	5.8	6.3
Y	31.7	29.9	28.6	25.8	27.2	30.6	30.9	33.1	29.5	28	28.3	34	25.8	29.8	34	7.7
Ho	1.14	1.14	1.05	0.94	1.02	1.12	1.13	1.18	1.03	1.05	1.04	1.19	0.94	1.09	1.19	6.6
Er	3.44	3.36	3.05	2.81	2.84	3.32	3.3	3.44	2.96	2.98	3.09	3.7	2.81	3.19	3.70	8.3
Tm	0.51	0.48	0.43	0.43	0.42	0.5	0.5	0.51	0.45	0.44	0.44	0.53	0.42	0.47	0.53	7.9
Yb	3.26	3.09	2.81	2.7	2.68	3.28	3.16	3.38	2.82	2.81	2.67	3.33	2.67	3.00	3.38	8.8
Lu	0.52	0.48	0.42	0.43	0.42	0.5	0.48	0.51	0.44	0.45	0.41	0.53	0.41	0.47	0.53	8.8
Σ REE	202.7	202.5	169.7	169.6	167.7	212.1	194.1	205.9	171.5	179.3	163.5	217.5	163.5	188.0	217.5	10.0
REO	243.7	243.3	204.1	203.9	201.6	254.9	233.4	247.7	206.3	215.6	196.6	261.5	196.6	226.0	261.5	10.0
L/H	7.09	7.34	6.36	7.12	6.60	7.54	6.93	7.07	6.46	7.25	6.27	7.24	6.27	6.94	7.54	5.7
EF	1.00	1.00	1.01	1.01	0.81	1.02	0.95	1.01	0.97	1.02	0.77	1.02	0.77	0.97	1.02	8.5
Recovery	5.47	94.53	11.67	88.33	3.63	96.37	5.26	94.74	12.72	87.28	4.57	95.43	3.63	50.00	96.37	85.9
Critical	74.13	72.86	64.9	61.39	63.17	75.28	72.88	75.89	65.62	65.63	63.71	79.91	61.39	69.61	79.91	8.5
Uncritical	54.92	54.9	45.33	46.42	45.17	58.53	51.78	55.96	45.74	48.22	43.54	59.28	43.54	50.82	59.28	10.8
Excessive	73.63	74.69	59.51	61.8	59.34	78.3	69.47	74.08	60.14	65.45	56.26	78.28	56.26	67.58	78.30	11.4
La _N / Lu _N	0.67	0.72	0.66	0.68	0.66	0.74	0.68	0.70	0.64	0.68	0.66	0.71	0.64	0.68	0.74	4.0
La _N / Sm _N	0.85	0.86	0.80	0.86	0.81	0.84	0.85	0.88	0.80	0.86	0.80	0.86	0.80	0.84	0.88	3.4
Gd _N / Lu _N	0.86	0.95	0.99	0.88	0.99	0.94	0.91	0.89	0.95	0.87	0.97	0.91	0.86	0.92	0.99	4.8
Y _N / Ho _N	1.10	1.04	1.08	1.08	1.05	1.08	1.08	1.11	1.13	1.05	1.08	1.13	1.04	1.08	1.13	2.6
Eu _N / Eu*	1.06	1.03	1.06	1.03	1.12	1.00	1.05	1.05	1.04	1.02	1.10	1.01	1.00	1.05	1.12	3.2
Ce _N / Ce _N *	0.95	0.97	0.94	0.94	0.95	0.95	0.95	0.93	0.95	0.96	0.93	0.94	0.93	0.95	0.97	1.0
Gd _N / Gd _N *	1.08	1.15	1.12	1.10	1.15	1.11	1.11	1.09	1.15	1.11	1.13	1.10	1.08	1.12	1.15	1.9
REYdef, rel%	36.57	35.99	38.23	36.19	37.67	35.49	37.54	36.85	38.26	36.60	38.96	36.75	35.49	37.09	38.96	2.7
C _{outl}	1.01	0.98	1.09	0.99	1.06	0.96	1.05	1.02	1.09	1.00	1.13	1.02	0.96	1.03	1.13	4.8

BA, bottom ash; ECO, economizer; ESP, Electrostatic precipitator; Mag, magnetic fraction; non-mag, non-magnetic fraction; CV, coefficient of variation; REO, rare earth elements as oxides; L/H, ratio between light REE and heavy REE; REYdef, rel%, $(Y+Nd+Eu+Tb+Dy+Er)/\Sigma REE$; C_{outl}, $((Nd+Eu+Tb+Dy+Er+Y)/\Sigma REE)/((Ce+Ho+Tm+Yb+Lu)/\Sigma REE)$