

Table S1. Major and trace element concentrations of different depth in the sediment core PC15

depth(cm)	major element(%)											trace element($\mu\text{g/g}$)			
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	MnO	TiO ₂	P ₂ O ₅	LOI	Co	Ni	Cu	Ba
0-10	48.03	12.89	11.60	9.62	7.31	3.32	0.78	0.19	1.90	0.19	3.52	70.9	244	152	127
20-30	48.12	13.23	11.55	8.86	6.79	3.50	0.91	0.24	1.95	0.22	4.14	72.0	219	164	142
40-50	49.26	12.38	11.57	9.55	8.29	2.87	0.63	0.16	2.03	0.23	2.29	64.8	216	121	169
58-70	46.86	13.91	12.35	6.71	5.44	3.87	1.30	0.68	2.11	0.25	5.76	123	202	265	192
80-92	46.99	13.92	12.20	7.14	5.72	3.91	1.14	0.20	2.11	0.22	5.60	79.0	172	213	169
100-110	50.69	15.43	9.17	3.44	2.48	4.44	2.74	1.06	1.23	0.69	7.84	153	274	519	765
120-130	51.62	15.44	8.48	3.30	2.04	4.21	2.87	1.45	0.98	0.71	8.08	202	367	687	1084
140-150	51.42	15.34	8.45	3.31	1.97	4.45	3.03	1.46	0.99	0.67	8.14	206	330	694	1291
160-170	51.32	15.47	8.41	3.32	1.94	4.43	2.94	1.51	0.96	0.62	8.21	215	352	696	1395
180-190	51.68	15.48	8.48	3.38	1.90	4.33	2.93	1.49	0.96	0.65	8.17	208	325	655	1638
200-210	51.35	15.33	8.38	3.38	1.91	4.53	3.21	1.38	0.93	0.64	8.19	208	320	658	1526
220-230	52.32	15.75	8.33	3.44	2.07	4.16	2.86	1.26	0.95	0.70	8.07	172	296	637	1430
240-250	51.72	15.95	8.01	3.44	2.10	4.37	3.09	1.17	0.92	0.68	8.07	151	248	604	1427
260-270	52.83	15.85	7.60	3.29	1.93	4.25	3.26	1.15	0.85	0.68	8.02	149	252	630	1838
280-290	52.50	15.51	7.44	3.22	1.90	4.41	3.48	1.19	0.82	0.71	8.13	155	259	666	1938
300-310	52.57	15.57	7.40	3.24	1.83	4.37	3.41	1.19	0.80	0.66	8.17	151	263	657	2005
320-330	52.88	15.68	7.41	3.21	1.74	4.33	3.29	1.17	0.79	0.68	8.35	150	268	635	2031
340-350	52.91	15.45	7.25	3.15	1.77	4.37	3.37	1.20	0.78	0.72	8.29	156	284	626	1828
360-370	52.74	15.38	7.21	3.14	1.84	4.41	3.45	1.22	0.76	0.79	8.28	162	303	636	1747
380-390	52.50	15.69	7.29	3.22	1.89	4.31	3.23	1.30	0.76	0.80	8.18	166	302	629	1711
400-410	53.04	15.65	7.32	3.29	1.87	4.29	3.15	1.34	0.79	0.75	8.22	171	305	646	1772
420-430	52.93	15.56	7.12	3.17	1.93	4.26	3.19	1.37	0.76	0.81	8.12	180	300	658	1765
440-450	53.18	15.42	7.09	3.17	1.91	4.32	3.39	1.36	0.77	0.78	8.00	172	318	666	2084
460-470	53.12	15.45	7.06	3.08	1.99	4.30	3.49	1.40	0.77	0.83	7.96	185	299	615	1758
480-490	53.17	15.72	7.09	3.01	2.21	4.33	3.36	1.52	0.76	0.98	7.78	191	309	608	845

500-510	52.44	15.65	7.10	2.93	2.34	4.22	3.12	1.59	0.74	1.08	8.11	191	357	559	514
520-530	52.11	15.65	7.18	2.91	2.43	4.29	3.27	1.68	0.73	1.13	8.06	197	386	561	377
540-550	51.89	15.84	7.31	2.90	2.70	4.11	2.98	1.70	0.73	1.25	7.86	188	388	555	391

Table S2. Rare earth element concentrations($\mu\text{g/g}$) and characteristics parameters of different depth in the sediment core PC15

depth(cm)	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y	$\Sigma\text{Ce}/\Sigma\text{Y}^*$	δCe^{**}	δEu^{**}	ΣREY
0-10	12.1	26.7	3.99	18.6	5.03	1.56	6.24	0.90	4.81	1.09	2.48	0.36	2.18	0.32	24.1	1.60	0.93	1.17	110.46
20-30	16.6	30.1	5.23	25.0	6.31	1.81	7.24	1.08	5.70	1.28	3.09	0.44	2.62	0.40	30.9	1.61	0.79	1.14	137.80
40-50	14.6	25.6	4.59	22.1	5.91	1.75	7.00	1.04	5.66	1.20	3.03	0.43	2.63	0.36	29.4	1.47	0.76	1.15	125.30
58-70	26.2	57.9	7.70	34.9	8.56	2.36	9.46	1.52	7.92	1.67	4.38	0.62	3.86	0.56	39.1	1.99	1.00	1.12	206.71
80-92	17.6	33.4	5.35	24.2	6.44	1.83	7.31	1.12	5.89	1.25	2.97	0.43	2.65	0.38	29.6	1.72	0.84	1.13	140.42
100-110	79.6	105	22.0	96.7	22.8	5.35	21.4	4.00	22.1	4.79	12.7	1.82	11.6	1.74	125	1.62	0.61	1.04	536.60
120-130	89.1	120	24.8	110	25.8	5.96	23.8	4.52	24.8	5.63	14.9	2.16	13.1	1.89	145	1.59	0.62	1.03	611.46
140-150	87.0	117	24.6	109	25.6	6.15	24.6	4.40	24.7	5.44	14.4	2.03	13.1	1.95	143	1.58	0.62	1.05	602.97
160-170	86.8	129	24.1	105	25.2	5.85	23.4	4.36	24.2	5.32	14.1	1.94	12.5	1.81	137	1.67	0.69	1.03	600.58
180-190	89.3	131	24.7	109	25.3	6.01	24.1	4.41	24.3	5.34	13.8	2.06	12.2	1.90	140	1.69	0.68	1.04	613.42
200-210	88.6	125	24.5	107	25.2	6.01	24.0	4.45	24.6	5.42	14.1	2.08	12.9	1.92	141	1.63	0.66	1.05	606.78
220-230	94.3	112	26.2	115	27.9	6.41	25.7	4.80	26.9	5.82	15.4	2.23	14.2	2.02	154	1.52	0.55	1.03	632.88
240-250	93.6	100	26.0	117	27.4	6.36	25.4	4.70	25.7	5.69	15.0	2.19	13.5	1.99	150	1.52	0.50	1.03	614.53
260-270	93.9	96.5	26.8	118	28.7	6.51	26.0	4.95	26.8	5.94	15.6	2.24	13.8	2.06	154	1.47	0.47	1.02	621.80
280-290	98.6	97.4	27.9	122	28.9	6.94	27.8	5.08	27.7	6.06	16.4	2.37	14.7	2.22	164	1.43	0.45	1.05	648.07
300-310	91.4	96.0	26.3	115	26.9	6.39	25.6	4.77	25.9	5.80	15.3	2.20	13.8	2.05	150	1.47	0.48	1.04	607.41
320-330	96.2	99.5	27.6	122	29.0	6.82	27.3	5.03	27.1	6.04	15.7	2.30	14.1	2.09	159	1.47	0.47	1.04	639.78
340-350	97.6	98.5	28.6	127	29.7	7.06	28.2	5.18	28.5	6.20	16.9	2.40	15.0	2.25	170	1.41	0.46	1.05	663.09
360-370	103	97.7	29.2	132	31.1	7.20	28.8	5.33	30.0	6.58	18.2	2.55	15.7	2.42	184	1.36	0.44	1.03	693.78
380-390	105	102	29.7	131	31.1	7.25	29.0	5.40	30.3	6.77	17.8	2.56	15.7	2.41	184	1.38	0.45	1.04	699.99
400-410	101	104	28.6	128	29.4	6.80	27.2	5.18	28.1	6.23	16.3	2.39	14.7	2.22	169	1.47	0.47	1.03	669.12
420-430	104	103	30.3	135	32.2	7.33	29.3	5.58	30.2	6.76	18.4	2.58	16.1	2.42	185	1.39	0.45	1.02	708.17
440-450	104	104	30.5	136	32.6	7.38	29.5	5.50	30.7	6.68	17.8	2.58	15.4	2.31	182	1.42	0.45	1.02	706.95
460-470	110	108	30.9	140	32.0	7.52	30.1	5.69	31.5	6.89	18.2	2.68	16.2	2.46	186	1.43	0.45	1.04	728.14
480-490	112	107	31.8	146	34.5	7.89	31.6	6.11	33.6	7.47	20.1	2.84	17.2	2.63	195	1.39	0.44	1.03	755.74
500-510	128	118	36.2	164	38.9	8.85	35.4	6.87	37.9	8.34	22.5	3.22	18.8	2.90	222	1.38	0.42	1.02	851.88

520-530	133	121	37.0	169	39.1	8.86	35.4	6.89	37.6	8.30	21.5	3.13	18.6	2.89	218	1.44	0.42	1.02	860.27
540-550	130	120	36.1	165	39.0	8.53	34.1	6.58	36.4	8.19	21.7	3.11	18.0	2.83	217	1.43	0.43	1.00	846.54

*: $\Sigma\text{Ce} = \text{La} + \text{Ce} + \text{Pr} + \text{Nd} + \text{Sm} + \text{Eu}$; $\Sigma\text{Y} = \text{Gd} + \text{Tb} + \text{Dy} + \text{Ho} + \text{Er} + \text{Tm} + \text{Yb} + \text{Lu} + \text{Y}$;

** : $\delta\text{Ce} = 2\text{Ce}_\text{N} / (\text{La}_\text{N} + \text{Pr}_\text{N})$; $\delta\text{Eu} = 2\text{Eu}_\text{N} / (\text{Sm}_\text{N} + \text{Gd}_\text{N})$. The North American Shale Composition was followed by [Ref. \[25\]](#).