Appendix 1 Major element concentrations (wt%) of Liuling Group sedimentary samples

Sample	SiO_2	Al_2O_3	FeO	Fe_2O_3	MgO	CaO	Na_2O	K_2O	MnO	TiO_2	P_2O_5	Loss	Total	CIA	Lith
Tongyusi Formation: Eryuhe section															
TY37	61.41	18.4	4.19	2.1	3.04	0.44	1.03	3.87	0.07	0.85	0.13	3.7	99.24	73	FGS
TY39	82.47	3.81	1.88	1.5	1.19	3.28	1.12	0.26	0.17	0.25	0.11	3.27	99.31	49	MSS
TY41	80.68	6.27	1.83	1.61	1.2	2.05	1.76	0.51	0.08	0.44	0.14	2.8	99.37	50	MSS
TY47	63.8	6.81	1.65	1.08	1.9	11.33	1.76	1.12	0.15	0.46	0.17	9	99.23	49	FGS
TY49	60.94	17.56	3.25	3.12	3.49	1.4	1.11	4.32	0.05	0.71	0.14	3.33	99.42	68	FGS
*Q104	78.33	7.24	1.72	1.43	1.49	2.03	0.68	1.72	0.06	0.51	0.16	4.16	99.53	64	MSS
*Q106	78.47	8.91	2.53	1.83	1.64	0.76	1.48	1.53	0.08	0.66	0.22	2.3	100.41	62	FGS
*Q120	79.55	7.26	2.55	0.6	1.3	2.21	0.16	1	0.09	0.49	0.17	4.6	99.98	82	FGS
*Q121	70.27	10.36	3.16	1.11	1.9	3.9	0.21	1.58	0.09	0.61	0.57	7.13	100.44	81	FGS
Qingshiya Formation: Banfangzi Section															
QS1	65.26	12.58	2.78	2.41	3.17	4.47	2.28	3.08	0.06	0.74	0.19	2.33	99.35	54	MSS
QS2	54.65	15.98	3.72	1.71	2.87	4.11	0.88	4.49	0.04	0.71	0.15	10	99.31	67	FGS
QS4	76.15	10.43	2.31	1.85	1.31	1.49	2.48	1.87	0.05	0.68	0.17	0.67	99.46	54	MSS
QS5	68.95	14.83	3.82	1.66	1.93	0.32	1.5	2.69	0.04	0.69	0.18	2.67	99.28	71	MSS
QS6	67.6	15.23	1.92	3.32	2.1	0.42	1.02	3.64	0.06	0.85	0.15	3.27	99.58	70	MSS
QS7	66.17	15.06	2.12	3.42	2.42	1.04	1.13	3.56	0.07	0.87	0.16	3.43	99.45	67	MSS
QS9	68.31	14.39	2.15	2.71	2.23	0.91	1.13	3.47	0.06	0.83	0.18	3.13	99.5	66	MSS
QS11	74.99	9.27	1.92	1.92	1.6	2.37	1.37	1.78	0.12	0.47	0.11	3.6	99.52	59	MSS
Qingshiya Formation: Zhashui Section															
ZS2	65.02	12.95	3.4	1.93	2.72	4.86	2.54	3.13	0.11	0.73	0.14	2.03	99.56	52	FGS
ZS3	66.47	12.64	2.85	2.72	3.07	5.09	1.79	2.53	0.11	0.76	0.17	1.44	99.64	59	FGS
ZS4	66.95	13.58	3.2	2.13	2.96	2.91	2.44	3.42	0.08	0.79	0.17	0.97	99.61	54	FGS
ZS5	67.56	11.31	2.5	2.05	2.56	6.21	1.95	2.52	0.11	0.67	0.15	2.04	99.63	55	FGS
Chigou Formation: Qingchuan Section															

QC1	70.16	10	2.1	1.79	2.38	5.66	1.64	1.83	0.1	0.6	0.16	3.32	99.74	58	FGS
QC2	69.48	9.47	1.95	2.14	2.6	5.78	1.74	2	0.1	0.71	0.18	3.43	99.58	55	FGS
QC3	67.94	10.45	2.1	2.42	2.81	5.79	1.81	2.04	0.1	0.7	0.16	3.35	99.67	56	FGS
QC4	65.1	12.4	3.05	2.55	3.57	3.76	2.4	2.17	0.11	0.73	0.18	3.6	99.62	55	FGS
QC5	63.18	12.59	2.9	2.71	3.78	5.33	1.73	3.64	0.11	0.81	0.2	2.57	99.55	57	FGS
QC7	61.42	14.81	3.75	2.66	3.79	3.39	2.63	3.84	0.09	0.81	0.17	2.16	99.52	54	FGS
QC8	69.86	10.01	1.75	1.91	2.48	5.77	1.15	2.67	0.1	0.57	0.16	3.31	99.73	60	FGS
QC9	61.56	15.15	3.4	2.87	3.83	1.97	2.44	5.98	0.06	0.72	0.15	1.45	99.58	52	FGS
QC10	73.44	7.64	1.1	1.24	1.68	6.13	1.93	1.41	0.07	0.41	0.11	4.52	99.68	49	MSS
QC11	60.59	15.49	3.1	2.81	3.86	1.29	1.56	8.33	0.06	0.72	0.17	1.65	99.63	53	FGS
QC14	59.79	15.29	2.75	3.94	4.55	5.14	1.27	3.87	0.1	0.81	0.19	1.9	99.6	65	FGS
QC15	61.96	14.07	3.2	3.55	4.06	3.82	2.08	4.42	0.1	0.88	0.18	1.18	99.5	55	FGS
QC16	62.48	13.89	2.5	3.49	3.9	5.92	1.18	3.11	0.1	0.79	0.18	2.05	99.59	66	FGS
QC18	62.52	14.33	3.8	2.45	4.18	3.9	1.64	4.29	0.08	0.83	0.2	1.28	99.49	59	FGS
Chigou Formation: Zhashui Section															
ZS55	62.42	18.06	2.5	3.4	2.76	0.49	0.39	5.46	0.04	0.71	0.13	3.13	99.5	71	FGS
ZS57	65.8	14.12	2.28	3.24	2.98	3.82	1.69	2.53	0.12	0.74	0.16	1.97	99.45	63	FGS
ZS59	60.61	18.62	2.23	3.91	3.11	0.67	0.44	4.61	0.07	0.72	0.09	4.4	99.48	74	FGS
ZS61	72.24	9.94	1.69	1.68	2.76	5.11	0.89	2.19	0.09	0.64	0.17	2.1	99.5	65	MSS
ZS62	62.87	14.83	3.77	3.06	3.93	3.53	1.98	3.25	0.08	0.85	0.21	0.97	99.33	60	FGS
ZS64	70.26	9.99	1.85	2.43	2.91	4.33	1.04	2.59	0.13	0.7	0.19	3.07	99.49	62	FGS
ZS65	70.3	12.27	1.92	2.71	2.23	3.51	2.5	2.48	0.11	0.72	0.2	0.6	99.55	53	FGS
Chigou Formation: Guofenglou Section															
GF1	80.6	7.61	2	0.96	1.47	2.86	0.67	1.72	0.04	0.47	0.14	1.2	99.74	65	MSS
GF2	81.31	7.82	1.55	1.1	1.22	2.47	0.39	2.26	0.04	0.45	0.11	1.09	99.81	68	MSS
GF3	65.49	14.88	2.65	2.7	2.35	2.53	3.97	3.01	0.03	0.77	0.18	1.13	99.7	51	FGS
GF4	70.44	13.31	2.45	1.1	2.03	2.21	1.43	3.92	0.06	0.79	0.22	1.7	99.66	60	MSS
GF5	75.2	10.25	2.4	0.88	1.79	1.76	1.52	3.82	0.05	0.71	0.19	1.13	99.71	53	MSS

GF6	69.02	11.53	1.95	2.85	3.67	4.1	0.97	2.87	0.1	0.7	0.2	1.76	99.72	65	FGS
GF7	67.01	14.37	2.5	2.07	2.41	2.76	1.83	5.31	0.08	0.69	0.19	0.49	99.71	55	FGS
GF10	74.6	10.35	2.9	0.99	2.61	1.77	2.54	1.86	0.06	0.54	0.12	1.29	99.62	52	FGS
GF11	75.74	9.63	2.8	1.09	2.2	1.57	2.4	2.33	0.07	0.82	0.16	0.85	99.65	51	MSS
GF13	71.16	11.68	3.45	1.33	2.42	2.98	1.98	2.75	0.09	0.71	0.15	0.88	99.58	55	MSS
GF16	65.98	12.7	2.9	2.2	2.77	4.91	1.69	3.19	0.09	0.76	0.19	2.24	99.61	58	FGS
GF17	64.79	12.68	3.1	2.02	3.02	6.4	2.5	3.19	0.1	0.66	0.18	0.96	99.6	52	FGS
GF18	68.74	11.23	1.95	2.43	2.56	5.99	2.61	2.28	0.11	0.6	0.19	1.04	99.73	50	FGS
GF22	70.01	10.83	2.25	1.56	2.43	5.35	2.93	2.33	0.08	0.53	0.14	1.25	99.69	47	FGS
GF24	75.3	10.35	1.9	1.55	2.03	2.22	2.05	2.67	0.06	0.63	0.14	0.87	99.77	52	MSS
Niuerchuan Formation: Niuerchuan Section															
NR66	66.04	13.92	2.38	3.15	3.06	4.42	1.88	2.23	0.1	0.77	0.17	1.37	99.49	62	FGS
*Q272	85.08	6.59	0.76	1.51	0.45	0.7	1.75	1.49	0.08	0.47	0.09	1.14	100.1	53	MSS
*Q274	84.29	6.61	0.81	1.08	0.52	1.1	2.11	1.65	0.07	0.32	0.08	1.37	100.01	48	MSS
*Q275	81.97	7.22	0.72	1.5	0.36	1.43	1.88	1.9	0.08	0.34	0.1	2.06	99.55	48	MSS
*Q314	78.88	9.1	1.82	1.35	1.33	0.57	2.19	1.51	0.05	0.56	0.15	2.21	99.71	59	MSS

Notes: Sample "*" are from He et al. (2005); FGS, deep grey fine-grained silty sandstone; MSS, light grey coarse-grained silty sandstone; CIA = Chemical Alteration Index after Nesbitt and Yong (1982). Calculated from mole fractions as molar $[Al_2O_3/(Al_2O_3 + CaO^* + Na_2O + K_2O)] \times 100$, where CaO* is CaO in silicates only. If the mole fraction of $CaO > Na_2O$, then we assumed that the moles of $CaO = Na_2O$ (McLennan et al., 1993).

Appendix 2 Trace element concentrations (ppm) and element ratios of Liuling Group clastic sediments

Sample	Sc	V	Cr	Co	Ni	Cu	Ga	Rb	Sr	Ba	Y	Zr	Hf	Nb	Ta	Cs	Pb	Th	U	Ba/Nb	Cr/Ni	V/Cr	V/Ni	Th/Sc	Cr/Th	Lith
Tongyusi Formation: Eryuhe section																										
TY37	18.8	129	124	18.1	53.5	17.2	24.3	181	55.1	680	31.6	316	8	18.4	1.4	11	24.3	17.2	2.7	37	2.3	1	2.4	0.9	7.2	FGS
TY39	3.3	24.3	33.1	5.8	16.6	173	4.1	9.9	80.4	55	16.6	122	3.2	4.9	0.4	0.5	18.5	5.1	0.9	11.3	2	0.7	1.5	1.6	6.5	MSS
TY41	6.3	41.9	51.9	10.2	18	23.6	7.3	22.6	39.7	118	18.7	209	5.6	8.6	0.7	1.3	5.3	9.2	1.6	13.8	2.9	0.8	2.3	1.4	5.6	MSS
TY47	5.3	35.1	39.5	8	17.2	10.3	7.2	50.9	192	238	25.1	364	9.5	10.8	0.9	4.1	13.4	9.8	2	22	2.3	0.9	2	1.9	4	FGS
TY49	15.8	123	105	19.6	48.8	4.5	24.4	200	139	782	31.3	314	8.2	17.7	1.4	12.7	13.8	17.1	2.9	44.2	2.2	1.2	2.5	1.1	6.1	FGS
*Q104	6.1	47	72	8.1	25	5.7	8.9	73	71	517	18.9	357	10	9.4	0.8		4.6	9.9	1.3	55	2.9	0.7	1.9	1.6	7.3	MSS
*Q106	8.2	53	85	12	43	42	11	67	74	248	26.6	402	11	12	1.3		6.9	12	1.9	20.7	2	0.6	1.2	1.5	7.1	FGS
*Q120	7.1	42	69	8.9	32	2.8	9.6	51	217	259	15.9	338	9.3	10	1.1		349	10	1.2	25.9	2.2	0.6	1.3	1.4	6.9	FGS
*Q121	10	61	74	13	42	4	12	70	258	805	19.3	222	6.4	15	1.3		321	9.7	1.7	53.7	1.8	0.8	1.5	1	7.6	FGS
Qingshiya Formation: Banfangzi Section																										
QS1	12.6	97.9	80.4	12.8	33.8	7.1	17.9	135	166	526	27.6	215	5	14.2	1	11.1	9.5	12.3	2.5	37	2.4	1.2	2.9	1	6.5	MSS
QS2	17.1	115	99.9	9.5	48	25.4	22.6	191	71.5	551	32.7	324	7.4	17.1	1.2	10.3	5.5	13.9	2.4	32.2	2.1	1.2	2.4	0.8	7.2	FGS
QS4	10.3	64.7	57.5	9.2	23.7	10.7	14.2	110	158	276	28.1	266	6.3	14.2	1.1	6.4	30.1	18.3	2.3	19.4	2.4	1.1	2.7	1.8	3.1	MSS
QS5	13.2	86	80.4	11.1	32.9	27.6	20.3	106	71	555	26	262	6.2	17	1.4	4.3	16.6	18.1	2.4	32.6	2.4	1.1	2.6	1.4	4.4	MSS
QS6	12	92.5	98.9	15.1	37.6	3.6	21.5	188	50.4	599	30.3	405	9.4	19.9	1.4	11	8	14.3	2.7	30.1	2.6	0.9	2.5	1.2	6.9	MSS
QS7	14.7	99	104	15	40.1	4.3	20	173	76.3	678	35.5	378	8.8	18.2	1.3	11	7.5	15.6	2.6	37.3	2.6	1	2.5	1.1	6.7	MSS
QS9	14	99.8	96.5	14.4	35.3	9.4	20.1	173	69.4	469	28.3	343	7.8	18.8	1.3	10.7	6.6	16	2.6	24.9	2.7	1	2.8	1.1	6	MSS
QS11	7.3	62.6	53	11.5	26.9	3.8	12.3	81.2	99.1	240	16.2	116	2.8	9.2	0.7	5.5	5	7.9	1.1	26	2	1.2	2.3	1.1	6.7	MSS
Qingshiya Formation: Zhashui Section																										
ZS2	14.2	84.2	72.4	15.8	31.4	6	17.1	145	132	573	33.2	311	7.8	15	1.2	17.5	9.5	14.4	2.6	38.2	2.3	1.2	2.7	1	5	FGS
ZS3	15.8	88.7	81.7	18.8	33.6	8.4	19.2	131	148	450	39	283	7.8	17.5	1.4	11	12.1	16.1	3.3	25.7	2.4	1.1	2.6	1	5.1	FGS

ZS4	14.9	100	81.6	16.6	32.5	8.2	18.3	157	129	902	33	344	8.5	17.8	1.4	12.6	10.4	15.6	3.1	50.7	2.5	1.2	3.1	1	5.2	FGS
ZS5	12.6	74.2	69.1	15.5	29.9	7.4	16.5	121	128	589	32.7	261	6.3	15.5	1.2	7	9.7	14.1	2.8	38	2.3	1.1	2.5	1.1	4.9	FGS
Chigou Formation: Qingchuan Section																										
QC1	12.4	77.1	69.5	13.7	26	10.4	15.5	78.1	171	437	28.3	173	4.2	13.1	1	4.6	13.6	10.6	2.3	33.4	2.7	1.1	3	0.9	6.6	FGS
QC2	12	72.1	73.8	12.3	25.2	9.9	15.2	68.3	205	374	32.1	188	5	12.9	1	4.5	19.4	12.1	2.5	29	2.9	1	2.9	1	6.1	FGS
QC3	14	85.9	73.5	14	28.9	11.4	17.4	71.5	175	626	33.8	201	4.8	14.1	1.2	3.9	19.5	12.2	2.7	44.4	2.5	1.2	3	0.9	6	FGS
QC4	17.7	88.9	83.8	17.9	33.8	24.1	19.6	112	146	313	35.7	265	6.3	15.7	1.2	5.8	15.2	12.9	2.4	19.9	2.5	1.1	2.6	0.7	6.5	FGS
QC5	16	99.5	87.8	17.5	36.3	33.5	20.9	168	207	743	34.8	211	5	20.7	1.4	13.3	25.6	13.9	2.8	35.9	2.4	1.1	2.7	0.9	6.3	FGS
QC7	18.6	97.8	94.3	19.6	38.1	15.1	21.9	179	215	1117	29.9	263	6.7	15.6	1.3	12.6	23.2	14.1	2.3	71.6	2.5	1	2.6	0.8	6.7	FGS
QC8	11.9	77.7	66.4	11.7	24.1	16	15.1	122	190	534	29.5	197	5.1	12.5	1	8.2	22	10.8	2.3	42.7	2.8	1.2	3.2	0.9	6.1	FGS
QC9	18.3	99	89.5	17.5	35	25.1	22.6	206	154	1125	27.1	324	7.9	15.7	1.3	14.4	28.6	13.6	2.2	71.7	2.6	1.1	2.8	0.7	6.6	FGS
C10	5.7	48.6	36.1	6.8	14.5	25	9.5	57.4	179	390	16.2	150	3.8	7.7	0.6	4.3	13	6.4	1.3	50.8	2.5	1.3	3.4	1.1	5.7	MSS
QC11	19.3	113	90.1	19	37.2	35.6	24.3	264	136	1686	28.8	348	8.3	16.9	1.3	15.5	28.9	14.7	2.3	99.8	2.4	1.3	3	0.8	6.1	FGS
QC14	19	113	98.8	20.4	40.3	15.8	23	171	177	676	34.4	221	5.5	16.6	1.3	11.1	25.6	15.8	3.5	40.7	2.5	1.1	2.8	0.8	6.3	FGS
QC15	18.3	92.6	94.3	18.9	38.2	10.4	22.3	178	230	752	31.2	301	7.2	16.8	1.3	13.4	24.2	15	2.5	44.8	2.5	1	2.4	0.8	6.3	FGS
QC16	16.9	94.3	83.8	17.6	34.9	10.8	20.9	144	185	539	33.5	193	4.6	15.3	1.2	8.9	21.8	13.6	3.3	35.2	2.4	1.1	2.7	0.8	6.2	FGS
QC18	18.6	117	92.6	19.1	37.8	36.8	23	189	189	713	33.5	281	6.8	17.3	1.4	12.2	24.7	16.3	3.4	41.2	2.4	1.3	3.1	0.9	5.7	FGS
Chigou Formation: Zhashui Section																										
ZS55	16.5	122	105	19.8	48.9	8.2	24.4	214	180	988	23.6	363	9.4	17.4	1.4	12.8	9	18.1	3.4	56.8	2.1	1.2	2.5	1.1	5.8	FGS
ZS57	14.9	108	95.7	18.2	41.7	5.2	20.5	126	556	1770	36.1	318	8.6	18.1	1.4	9.3	15	17.1	3.7	97.8	2.3	1.1	2.6	1.1	5.6	FGS
ZS59	19.9	139	118	18.2	48.3	3.9	28.1	190	196	1018	32.6	337	7.7	18.1	1.3	7.6	10.6	16.3	2.5	56.2	2.4	1.2	2.9	0.8	7.2	FGS
ZS61	10.3	65.7	76.4	9.7	25.7	11.3	13.5	103	129	388	29.4	269	5.9	14	1	5.9	44.1	13.2	2.2	27.7	3	0.9	2.6	1.3	5.8	MSS
ZS62	16.8	115	106	18.5	45.6	15.2	23.4	188	137	603	34.4	325	7.2	19	1.3	14.3	15.8	15.7	2.7	31.7	2.3	1.1	2.5	0.9	6.8	FGS
ZS64	10.3	87.8	86.1	13.6	31.7	7.9	14.9	113	147	441	31.1	243	5.6	13.9	1	6.5	12.2	14.1	2.5	31.7	2.7	1	2.8	1.4	6.1	FGS
ZS65	11.4	88.2	78.6	11.5	31.9	3.5	17	103	147	517	28.4	164	3.7	13.9	0.9	5.8	22	10.6	2.1	37.2	2.5	1.1	2.8	0.9	7.4	FGS
Chigou Formation: Guofenglou Section																										

GF1	5.5	40	36.7	7.8	18	11.7	10.3	70.3	126	410	18.5	141	3.2	9.5	0.8	2.9	2.1	8.5	1.3	43.3	2	1.1	2.2	1.5	4.3	MSS
GF2	5.6	43.9	36.7	6	18.5	6.3	10.8	82.9	109	750	15.1	170	4.1	10	0.8	3.9	4.6	8.6	1.2	75.4	2	1.2	2.4	1.5	4.3	MSS
GF3	16.1	91.9	82.9	12.4	28	9.6	20.2	134	239	468	36.3	285	7.1	15.5	1.2	8	14.8	14.4	2.6	30.2	3	1.1	3.3	0.9	5.8	FGS
GF4	14.6	87	76.9	14.8	26.6	22.4	18.7	131	210	614	28.8	347	8.1	16.6	1.3	6.8	13.2	14	2.9	37	2.9	1.1	3.3	1	5.5	MSS
GF5	10.9	71.7	68.5	9.9	18.5	28	14.4	115	123	641	25	226	5.5	13.2	1.1	4.9	9	15.8	2	48.6	3.7	1	3.9	1.4	4.3	MSS
GF6	13.5	81.7	70.1	15.2	27.3	7.5	16.8	129	333	644	27.1	208	5	14.6	1.1	5.8	9.4	12.6	2.4	44.1	2.6	1.2	3	0.9	5.6	FGS
GF7	16.3	91.2	79.4	11.7	25.7	8.6	19.5	177	279	921	27.3	310	7.6	15.4	1.2	7.5	62.3	13.9	2.5	59.8	3.1	1.1	3.5	0.9	5.7	FGS
GF10	9.1	65.3	48.1	11.9	21.9	56	14	82.9	108	423	21.8	148	3.5	11.4	2.3	6.7	8.5	8	1.5	37.1	2.2	1.4	3	0.9	6	FGS
GF11	10.7	66.9	71.4	10.2	17.5	10	14	70.7	116	596	18.1	220	5.4	14.1	1.3	5.8	13.1	18.5	2.4	42.3	4.1	0.9	3.8	1.7	3.9	MSS
GF13	12.2	64.4	61.6	13	25.7	13	16.4	120	128	596	23.4	236	5.6	13	1.1	9.7	19.2	11.3	1.7	45.8	2.4	1	2.5	0.9	5.5	MSS
GF16	15.5	92.9	83.9	15.6	32.5	12.2	19.7	149	467	716	33.8	221	5.3	16.6	1.3	10.3	24.2	14.6	2.2	43.1	2.6	1.1	2.9	0.9	5.7	FGS
GF17	17.2	78.5	72.5	17.8	32.4	29.9	18.7	147	217	656	35.5	263	5.8	14	1.2	9.2	25.6	12.3	2.2	46.9	2.2	1.1	2.4	0.7	5.9	FGS
GF18	13.2	72.6	67	14.4	25.8	17.4	16.7	104	219	532	34.1	141	3.8	14.4	1.2	4.2	20.1	11.8	2.5	36.9	2.6	1.1	2.8	0.9	5.7	FGS
GF22	11.2	70.5	57.8	12.7	23.2	15.2	14.9	93.7	253	638	27.6	174	4.4	11.5	1	6.1	17.8	10.9	2	55.5	2.5	1.2	3	1	5.3	FGS
GF24	10.4	71.1	64	10.5	22.8	133	14.7	107	159	530	38.1	231	5.5	13.3	1.1	6.7	18.8	14.2	2.1	39.8	2.8	1.1	3.1	1.4	4.5	MSS
Niuerchuan Formation: Niuerchuan Section																										
NR66	16.1	96.4	98.5	16.4	42.9	3.3	21.3	129	124	456	34.4	299	6.7	17.1	1.2	5.8	5.6	14.1	3.1	26.7	2.3	1	2.2	0.9	7	FGS
*Q272	3.6	29	38	6.7	18	5.7	7.8	47	39	224	16.6	266	7	7.4	0.9		8.6	8.4	1.2	30.3	2.1	0.8	1.6	2.3	4.5	MSS
*Q274	3.5	24	32	6.6	15	3.1	7.8	52	50	314	12.3	198	5.3	6.4	0.8		29	7	1.4	49.1	2.1	0.8	1.6	2	4.6	MSS
*Q275	4	28	37	8.2	20	3.7	9.1	65	88	494	14.4	155	4.3	6.8	0.8		6.9	7	1.2	72.6	1.9	0.8	1.4	1.8	5.3	MSS
*Q314	6.6	41	47	15	25	5.8	11	54	53	254	17.1	324	8.9	13	1.5		6	11	1.8	19.5	1.9	0.9	1.6	1.7	4.3	MSS

Notes: Sample "*" are from He et al. (2005); FGS, deep grey fine-grained silty sandstone; MSS, light grey coarse-grained silty sandstone.

Appendix 3 Rare earth elements and element ratios of Liuling Group clastic sediments

Sample	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	∑REE	LREE /HREE	La/Yb	La_N /Yb_N	La_N /Sm_N	Gd_N /Yb_N	Eu/Eu*	Ce/Ce*	Ba/La	Th/La	La/Nb	Lith
Tongyusi Formation: Eryuhe section																										
TY37	48.8	86.7	11.1	40.6	7.29	1.68	6.41	0.99	5.78	1.15	3.36	0.47	3.34	0.48	218.15	8.85	14.61	9.87	4.21	1.56	0.75	0.87	13.93	0.35	2.65	FGS
TY39	14	27.6	3.46	14.3	2.9	0.63	2.83	0.49	2.93	0.59	1.64	0.24	1.55	0.22	73.38	5.93	9.03	6.1	3.04	1.48	0.67	0.93	3.93	0.36	2.89	MSS
TY41	22.8	41.6	5.05	20.4	3.77	0.93	3.59	0.58	3.5	0.69	2.06	0.3	2.08	0.33	107.67	7.14	10.96	7.41	3.81	1.4	0.77	0.91	5.18	0.4	2.66	MSS
TY47	28.6	53	6.93	26.6	4.96	1.04	4.48	0.75	4.49	0.87	2.58	0.37	2.52	0.37	137.56	7.31	11.35	7.67	3.63	1.44	0.67	0.88	8.32	0.34	2.65	FGS
TY49	45.9	90.1	10.1	37.7	6.52	1.59	5.9	0.97	5.75	1.14	3.45	0.49	3.38	0.46	213.44	8.84	13.58	9.18	4.43	1.41	0.78	0.98	17.04	0.37	2.59	FGS
*Q104	25.5	52.4	5.1	20.6	3.34	0.82	3.99	0.66	3.52	0.67	2.07	0.3	2.18	0.38	121.53	7.77	11.7	7.9	4.81	1.48	0.69	1.08	20.27	0.39	2.71	MSS
*Q106	32.6	63	7.48	27.3	4.92	1.17	5.34	0.83	5.05	0.98	2.87	0.4	2.92	0.43	155.31	7.18	11.16	7.54	4.17	1.48	0.7	0.95	7.61	0.37	2.72	FGS
*Q120	25.2	44.2	4.87	18	3.61	0.77	3.78	0.59	3.59	0.66	1.71	0.26	1.87	0.27	109.38	7.53	13.48	9.11	4.39	1.64	0.64	0.93	10.28	0.4	2.52	FGS
*Q121	25.5	53.1	6.2	26.3	5.09	1.31	4.47	0.78	3.79	0.73	2.11	0.3	2.2	0.33	132.21	7.9	11.59	7.83	3.15	1.65	0.84	0.99	31.57	0.38	1.7	FGS
Qingshiya Formation: Banfangzi Section																										
QS1	37.7	66.6	8.67	32	5.44	1.31	4.98	0.79	4.55	0.91	2.78	0.39	2.68	0.38	169.18	8.61	14.07	9.51	4.36	1.51	0.77	0.86	13.95	0.33	2.65	MSS
QS2	45.9	83.2	10.1	38.1	6.89	1.57	6.11	0.95	5.48	1.08	3.16	0.43	3.02	0.45	206.44	8.91	15.2	10.27	4.19	1.64	0.74	0.91	12	0.3	2.68	FGS
QS4	43.8	79.5	9.51	34.3	6.11	1.25	5.39	0.86	4.85	0.95	2.8	0.41	2.73	0.4	192.85	9.42	16.04	10.84	4.51	1.6	0.67	0.91	6.3	0.42	3.08	MSS
QS5	51.9	92.6	11.1	41.4	6.82	1.47	5.97	0.88	4.7	0.93	2.74	0.4	2.75	0.4	224.06	10.86	18.87	12.75	4.79	1.76	0.7	0.9	10.69	0.35	3.05	MSS
QS6	50.8	91.2	11.2	40.7	7.01	1.56	6.32	0.92	5.09	1	2.97	0.41	2.87	0.41	222.46	10.05	17.7	11.96	4.56	1.78	0.72	0.9	11.79	0.28	2.55	MSS
QS7	46.2	82.3	9.66	36.8	6.45	1.47	6.05	0.98	5.83	1.15	3.43	0.48	3.3	0.48	204.57	8.36	14	9.46	4.51	1.49	0.72	0.91	14.68	0.34	2.54	MSS
QS9	50.4	90.1	11.2	40.8	7.1	1.49	6.1	0.9	4.89	0.95	2.77	0.4	2.82	0.43	220.35	10.37	17.87	12.08	4.47	1.75	0.69	0.89	9.31	0.32	2.68	MSS
QS11	27.3	49	6.1	21.7	3.88	0.9	3.37	0.53	2.84	0.55	1.61	0.22	1.55	0.22	119.77	9.91	17.61	11.9	4.43	1.76	0.76	0.89	8.79	0.29	2.96	MSS
Qingshiya Formation: Zhashui Section																										
ZS2	43.7	81.6	9.62	35.9	6.58	1.46	6.06	0.99	5.87	1.1	3.37	0.55	3.38	0.52	200.7	8.12	12.93	8.74	4.18	1.45	0.71	0.93	13.11	0.33	2.91	FGS

ZS3	50.7	93.7	11	40.7	7.51	1.6	6.93	1.13	6.67	1.32	4.13	0.63	4.06	0.62	230.7	7.99	12.49	8.44	4.25	1.38	0.68	0.93	8.88	0.32	2.9	FGS
ZS4	50.8	92.5	10.5	40.5	7.38	1.63	6.4	1.01	6.22	1.17	3.53	0.56	3.46	0.5	226.16	8.83	14.68	9.92	4.33	1.5	0.72	0.94	17.76	0.31	2.85	FGS
ZS5	42.7	79.4	9.77	36.1	6.89	1.48	6.26	1.01	5.98	1.17	3.4	0.527	3.52	0.49	198.7	7.82	12.13	8.2	3.9	1.44	0.69	0.91	13.79	0.33	2.75	FGS
Chigou Formation: Qingchuan Section																										
QC1	38.1	68	7.99	30.4	5.5	1.12	5.33	0.83	5.03	0.95	2.86	0.48	3.08	0.45	170.12	7.89	12.37	8.36	4.36	1.4	0.63	0.91	11.47	0.28	2.91	FGS
QC2	44	76.2	9.08	32.1	6.47	1.22	6.07	0.98	5.73	1.1	3.27	0.53	3.35	0.49	190.6	7.8	13.13	8.88	4.28	1.47	0.59	0.89	8.5	0.28	3.41	FGS
QC3	38.9	72.9	8.61	32.6	6.14	1.46	6.04	1.04	5.98	1.18	3.45	0.52	3.45	0.49	182.76	7.18	11.28	7.62	3.99	1.42	0.73	0.93	16.09	0.31	2.76	FGS
QC4	42.6	76.6	8.92	33.3	6.17	1.28	6.31	0.98	5.9	1.15	3.53	0.57	3.88	0.58	191.78	7.32	10.98	7.42	4.35	1.32	0.63	0.92	7.35	0.3	2.71	FGS
QC5	42.3	82	9.69	34.5	6.55	1.58	6.17	1.03	6.27	1.22	3.71	0.56	3.35	0.5	199.43	7.68	12.63	8.53	4.06	1.49	0.76	0.95	17.57	0.33	2.04	FGS
QC7	44.8	82.9	9.28	32.5	5.9	1.57	5.97	0.93	5.39	1.03	3.19	0.47	3.15	0.51	197.59	8.5	14.22	9.61	4.78	1.54	0.81	0.95	24.93	0.31	2.87	FGS
QC8	37.9	65	7.63	28.6	5.18	1.23	5.25	0.84	5	0.97	2.84	0.43	2.8	0.45	164.12	7.77	13.54	9.15	4.61	1.52	0.72	0.9	14.09	0.28	3.03	FGS
QC9	38.5	71.8	8.25	30.6	5.57	1.51	5.28	0.86	4.91	0.95	2.87	0.47	2.88	0.42	174.87	8.3	13.37	9.03	4.35	1.49	0.85	0.94	29.22	0.35	2.45	FGS
C10	22.1	36.5	4.63	17.7	3.24	0.84	3.09	0.51	2.94	0.58	1.72	0.27	1.64	0.25	96.01	7.65	13.48	9.11	4.29	1.53	0.81	0.85	17.65	0.29	2.88	MSS
QC11	44.1	83.9	9.36	35.2	5.93	1.69	5.97	0.89	5.17	1.01	3.02	0.49	3.28	0.52	200.53	8.77	13.45	9.09	4.68	1.48	0.87	0.97	38.23	0.33	2.61	FGS
QC14	46.5	86.7	9.69	36.2	7.15	1.53	6.16	1.07	6.36	1.23	3.78	0.58	3.66	0.54	211.15	7.97	12.7	8.59	4.09	1.36	0.7	0.96	14.54	0.34	2.8	FGS
QC15	42.2	78.1	9.18	34.7	6.1	1.45	5.56	0.94	5.45	1.03	3.27	0.48	3.11	0.46	192.03	8.39	13.57	9.17	4.35	1.45	0.76	0.93	17.82	0.36	2.51	FGS
QC16	42.1	79.8	9.16	33.2	6.11	1.26	6.25	0.99	5.73	1.11	3.27	0.49	3.33	0.48	193.28	7.87	12.64	8.54	4.34	1.52	0.62	0.95	12.8	0.32	2.75	FGS
QC18	46.1	82.2	8.89	31.3	5.67	1.3	5.73	0.94	5.61	1.07	3.3	0.52	3.71	0.52	196.87	8.14	12.43	8.4	5.12	1.25	0.7	0.95	15.47	0.35	2.66	FGS
Chigou Formation: Zhashui Section																										
ZS55	48.4	91.9	11	41.4	6.84	1.63	5.82	0.86	4.78	0.89	2.61	0.4	3.02	0.46	220.01	10.59	16.03	10.83	4.45	1.56	0.79	0.93	20.41	0.37	2.78	FGS
ZS57	46.1	86.4	10.8	40.7	7.28	1.81	6.64	1.09	6.59	1.32	3.94	0.59	4.19	0.59	218.03	7.67	11	7.43	3.99	1.28	0.8	0.91	38.39	0.37	2.55	FGS
ZS59	47.3	84.8	10.2	39.8	6.71	1.64	6.65	0.98	5.67	1.09	3.18	0.44	3.27	0.46	212.19	8.68	14.46	9.77	4.44	1.65	0.75	0.9	21.52	0.34	2.61	FGS
ZS61	36.6	64.1	8.34	30.8	5.46	1.14	5.12	0.83	4.72	0.96	2.79	0.41	2.81	0.42	164.5	8.05	13.02	8.8	4.22	1.48	0.66	0.86	10.6	0.36	2.61	MSS
ZS62	48.2	90	11	40.6	6.93	1.69	6.64	1.03	5.97	1.18	3.54	0.49	3.33	0.46	221.06	8.69	14.47	9.78	4.38	1.62	0.76	0.92	12.51	0.33	2.54	FGS
ZS64	37.8	64	8.74	32.7	6	1.22	5.42	0.86	4.99	1.03	3.07	0.44	2.89	0.42	169.58	7.81	13.08	8.84	3.97	1.52	0.65	0.83	11.67	0.37	2.72	FGS
ZS65	37.3	65.9	8.64	31.6	5.75	1.33	5.37	0.81	4.66	0.9	2.6	0.36	2.53	0.34	168.09	8.49	14.74	9.96	4.08	1.72	0.73	0.86	13.86	0.28	2.68	FGS

Chigou Formation: Guofenglou Section																									
GF1	31.1	55.5	6.63	24.4	4.48	0.97	4.03	0.6	3.4	0.63	1.88	0.31	1.96	0.28	136.17	9.33	15.87	10.72	4.37	1.67	0.7	0.91	13.18	0.27	3.28	MSS
GF2	32	55.1	6.95	25.6	4.62	1.05	3.69	0.59	3.2	0.59	1.73	0.25	1.73	0.24	137.34	10.34	18.5	12.5	4.36	1.73	0.78	0.87	23.44	0.27	3.22	MSS
GF3	48.6	79.6	10.7	40.4	7.52	1.61	7.07	1.13	6.63	1.21	3.63	0.55	3.38	0.51	212.54	7.75	14.38	9.72	4.07	1.7	0.67	0.82	9.63	0.3	3.14	FGS
GF4	47.8	88	10.3	38.8	7.36	1.47	6.5	1	5.54	1.03	2.84	0.43	2.73	0.41	214.2	9.39	17.51	11.83	4.09	1.93	0.65	0.93	12.85	0.29	2.88	MSS
GF5	47.2	86.7	9.85	35.5	6.38	1.28	5.48	0.88	4.66	0.88	2.59	0.39	2.56	0.41	204.76	10.4	18.44	12.46	4.66	1.73	0.66	0.94	13.58	0.33	3.58	MSS
GF6	38.3	73.5	8.54	31	5.82	1.27	5.23	0.89	5.08	0.94	2.98	0.46	2.87	0.44	177.32	8.32	13.34	9.02	4.14	1.48	0.7	0.95	16.81	0.33	2.62	FGS
GF7	38.3	70	8.31	30.9	5.69	1.39	5.56	0.86	5.26	0.93	2.91	0.46	2.99	0.44	174	7.89	12.81	8.66	4.24	1.51	0.76	0.92	24.05	0.36	2.49	FGS
GF10	32.7	51.8	7.21	27.3	5.34	1.18	4.93	0.76	4.26	0.73	2.18	0.33	1.96	0.3	140.98	8.05	16.68	11.27	3.85	2.04	0.7	0.79	12.94	0.24	2.87	FGS
GF11	52.5	98.4	10.7	36.9	6.16	1.21	5.48	0.78	3.84	0.66	1.68	0.21	1.4	0.2	220.13	14.36	37.5	25.34	5.36	3.17	0.64	0.97	11.35	0.35	3.72	MSS
GF13	37.8	70.6	8.18	28.5	5.11	1.2	4.84	0.78	4.21	0.79	2.41	0.38	2.36	0.38	167.54	9.3	16.02	10.82	4.66	1.66	0.74	0.94	15.77	0.3	2.91	MSS
GF16	43.1	81.9	9.58	35.8	6.76	1.46	6.21	1.01	6.19	1.16	3.53	0.52	3.16	0.5	200.88	7.95	13.64	9.22	4.01	1.59	0.69	0.94	16.61	0.34	2.6	FGS
GF17	37.6	69.8	8.46	31.9	6.25	1.32	6.52	1.03	6.12	1.24	3.77	0.57	3.57	0.51	178.66	6.6	10.53	7.12	3.79	1.48	0.63	0.92	17.45	0.33	2.69	FGS
GF18	40.4	74.1	8.92	33.4	6.21	1.32	6.3	1.02	5.82	1.07	3.28	0.52	3.36	0.49	186.2	7.46	12.02	8.13	4.09	1.52	0.64	0.91	13.17	0.29	2.81	FGS
GF22	39.1	70.3	8.08	29.4	5.04	1.17	5.35	0.83	4.83	0.92	2.78	0.45	2.92	0.41	171.58	8.22	13.39	9.05	4.88	1.48	0.69	0.93	16.32	0.28	3.4	FGS
GF24	34.3	65.7	7.99	29.8	5.79	1.34	5.62	1	6.61	1.31	4.28	0.67	4.11	0.62	169.14	5.93	8.35	5.64	3.73	1.11	0.72	0.93	15.45	0.41	2.58	MSS
Niuerchuan Formation: Niuerchuan Section																									
NR66	44.9	82.1	10.1	36.6	6.78	1.44	6.24	0.94	5.6	1.09	3.33	0.48	3.25	0.46	203.31	8.44	13.82	9.34	4.17	1.56	0.68	0.9	10.16	0.31	2.63	FGS
*Q272	27.1	47.8	5.59	21.4	3.31	0.87	3.43	0.56	3.05	0.61	1.8	0.25	1.84	0.27	117.88	8.91	14.73	9.95	5.15	1.51	0.79	0.91	8.27	0.31	3.66	MSS
*Q274	21.1	36.3	4.63	16.6	2.68	0.69	2.64	0.3	2.35	0.42	1.36	0.19	1.43	0.21	90.9	9.14	14.76	9.97	4.96	1.5	0.79	0.86	14.88	0.33	3.3	MSS
*Q275	18	33	3.96	15.4	2.68	0.71	2.83	0.37	2.69	0.55	1.54	0.23	1.59	0.23	83.78	7.28	11.32	7.65	4.23	1.44	0.79	0.92	27.44	0.39	2.65	MSS
*Q314	32.5	60.6	6.56	27.2	4.24	1.06	4.57	0.55	3.32	0.62	1.94	0.2	1.9	0.28	145.54	9.8	17.11	11.56	4.82	1.95	0.74	0.97	7.82	0.34	2.5	MSS

Notes: Sample "*" are from He et al. (2005); FGS, deep grey fine-grained silty sandstone; MSS, light grey coarse-grained silty sandstone; REE chondrite-normalizing factors from Taylor and McLennan (1985).