Supplementary Materials Table S1. Major element (%) and trace and rare earth element (×10–6) analysis data of Carboniferous sandstones from the Alake Lake area.

	Halaguole Fm									Haoteluowa Fm						
Sample	11091–12	11091–13	11091–14	11091–15	11091–18	11091–19	11091–20	11091–22	11121–14	11085–3	11086–4	11086–9	11086–13	11086–14	11086–16	11099–20
SiO_2	65.44	70.94	75.18	67.56	60.25	66.95	69.18	67.39	74.98	65.59	78.02	76.72	70.94	66.04	62.13	74.88
TiO_2	0.56	0.33	0.44	0.49	0.53	0.43	0.44	0.10	0.15	0.64	0.18	0.21	0.40	0.60	0.78	0.26
Al_2O_3	11.60	10.72	11.23	11.69	12.94	11.71	11.50	13.72	14.85	11.06	11.92	12.72	15.05	14.05	18.70	11.12
TFe_2O_3	4.32	2.61	2.64	2.93	4.88	3.21	4.18	1.46	1.09	4.06	1.29	1.55	3.52	4.55	7.67	2.38
MnO	0.06	0.04	0.03	0.04	0.11	0.22	0.10	0.20	0.01	0.04	0.01	0.03	0.06	0.10	0.08	0.02
MgO	1.28	1.04	0.87	1.20	1.55	0.89	1.26	0.79	0.82	3.09	0.29	0.36	0.87	1.58	2.12	2.50
CaO	5.06	4.13	1.74	5.34	7.17	5.88	4.16	5.53	0.87	5.71	0.65	0.71	0.86	3.85	0.24	1.94
Na_2O	1.77	2.39	2.52	2.24	1.49	2.43	2.54	1.28	0.34	0.26	2.82	3.51	3.56	1.78	1.19	1.16
K_2O	3.34	2.86	2.45	2.47	2.56	1.89	1.46	3.09	3.72	1.97	3.31	2.57	2.32	2.28	3.42	2.45
P_2O_5	0.11	0.08	0.07	0.09	0.11	0.08	0.09	0.02	0.02	0.14	0.04	0.04	0.07	0.14	0.10	0.05
LOI	6.61	5.11	2.77	6.21	8.23	6.38	4.84	6.59	3.00	7.19	1.59	1.53	2.43	5.33	3.53	3.68
SUM	100.15	100.24	99.92	100.25	99.81	100.06	99.75	100.17	99.86	99.76	100.13	99.95	100.07	100.29	99.97	100.44
Li	23.6	16.2	34.3	31.4	38.0	27.8	31.9	11.4	14.8	57.5	16.0	13.5	39.4	36.6	52.5	32.3
Be	1.56	1.43	1.61	1.56	2.18	1.63	1.65	4.20	1.39	1.65	2.17	2.13	3.33	1.96	2.90	1.82
Sc	9.27	6.04	7.03	7.93	10.2	6.92	7.06	10.0	3.31	9.30	3.59	5.43	9.30	11.1	17.8	5.16
V	58.6	43.8	47.6	57.6	60.9	39.8	42.2	7.88	6.54	58.2	16.9	18.2	39.0	70.2	113	20.8
Cr	46.3	33.3	35.6	44.3	44.4	31.4	34.4	4.43	2.64	40.2	15.8	14.9	23.7	51.2	69.7	12.1
Co	7.61	5.57	5.33	5.15	10.2	6.62	7.23	1.10	1.22	7.88	0.82	2.10	5.37	10.9	15.3	3.71
Ni	13.6	11.0	10.1	10.2	21.7	14.8	14.6	5.00	4.09	14.4	3.93	4.88	11.3	28.0	38.8	6.91
Cu	10.7	9.46	7.80	10.9	13.6	8.14	7.19	2.88	1.12	11.0	4.16	2.83	14.1	20.8	27.7	4.80
Zn	56.7	37.9	39.7	42.0	62.0	46.5	50.5	42.8	18.3	60.0	29.0	32.0	74.0	57.1	95.5	49.4
Ga	13.2	11.5	12.8	13.4	15.5	13.4	13.9	21.6	15.9	14.2	13.9	15.1	19.4	17.0	23.6	13.2
Rb	140	123	107	112	120	78.8	67.0	118	142	81.6	125	99.2	115	96.3	151	106
Sr	115	114	131	157	180	213	179	126	160	156	79.1	76.9	186	184	107	48.5
Y	28.8	15.7	24.3	24.9	31.6	27.5	27.1	117	17.6	35.0	21.3	24.7	41.9	28.8	29.4	31.8
Zr	386	119	226	267	207	256	252	122	80.9	282	145	170	207	207	183	124
Nb	11.7	6.76	10.4	11.2	12.2	9.97	10.5	37.3	11.7	12.9	13.5	13.0	20.3	11.6	13.9	12.0
Sn	3.03	1.99	2.36	2.76	2.82	2.36	2.17	7.27	1.68	2.68	3.75	3.21	5.39	2.25	3.21	2.55
Cs	10.7	6.67	8.61	9.81	15.7	9.61	10.1	9.47	5.01	5.70	5.09	3.10	5.20	4.32	7.84	4.61
Ba	448	461	400	365	273	253	212	335	706	423	624	706	484	351	560	430
La	43.1	18.1	32.1	32.1	41.0	33.7	34.0	20.2	17.1	42.6	29.4	31.9	43.0	30.5	32.3	31.0
Ce	89.2	36.8	64.6	64.0	79.7	66.6	68.1	46.8	33.8	86.1	54.5	57.5	86.8	61.9	66.0	61.2
Pr	10.2	4.19	7.26	7.38	9.00	7.66	7.64	6.42	3.28	8.69	6.25	6.79	9.62	7.07	7.65	6.68
Nd	37.7	15.4	26.2	26.4	34.0	28.0	27.8	28.3	10.4	30.7	21.6	24.4	35.0	26.9	29.0	24.0
Sm	7.44	3.04	5.09	5.27	6.89	5.67	5.50	10.7	1.92	5.72	4.37	5.04	7.17	5.46	5.48	4.78
Eu	0.99	0.73	0.92	0.81	1.26	1.01	0.91	0.27	0.39	1.00	0.48	0.79	0.85	1.28	1.03	0.80
Gd	6.32	2.78	4.56	4.55	6.06	4.97	4.96	15.2	1.90	5.54	3.61	4.28	6.83	4.86	5.01	4.95
Tb	0.98	0.47	0.73	0.74	0.92	0.81	0.82	3.14	0.37	0.90	0.60	0.72	1.16	0.79	0.82	0.88
Dy	5.14	2.78	4.24	4.24	5.40	4.81	4.69	21.0	2.58	5.67	3.64	4.21	6.95	4.77	5.12	5.46
Ho	1.00	0.53	0.83	0.87	1.05	0.93	0.89	4.17	0.55	1.18	0.75	0.83	1.39	0.95	1.05	1.06
Er	2.96	1.58	2.42	2.41	2.95	2.61	2.62	11.1	1.78	3.46	2.16	2.37	4.05	2.74	3.16	3.13
Tm	0.43	0.23	0.36	0.37	0.43	0.38	0.39	1.57	0.29	0.52	0.34	0.36	0.61	0.41	0.49	0.47
Yb	2.98	1.61	2.42	2.52	2.91	2.51	2.64	9.72	2.11	3.42	2.21	2.37	3.98	2.73	3.31	3.20
Lu	0.44	0.23	0.35	0.36	0.43	0.38	0.40	1.35	0.33	0.53	0.33	0.35	0.59	0.40	0.47	0.46
Hf	10.1	3.18	6.13	7.04	5.42	6.69	6.43	5.76	3.01	7.30	4.31	4.73	5.94	5.57	5.01	3.90
Ta	0.79	0.50	0.78	0.87	0.88	0.79	0.78	2.81	1.10	0.90	1.07	0.96	1.62	0.84	0.99	0.99
Tl	0.95	0.93	0.71	0.79	0.69	0.42	0.33	0.87	0.99	0.54	0.85	0.60	0.69	0.50	0.82	0.63
Pb	19.4	21.5	19.4	19.1	21.1	20.3	20.7	32.2	5.49	27.4	20.0	11.6	35.9	19.5	14.9	5.80
Th	25.4	9.48	14.7	17.9	14.2	12.8	14.0	35.9	16.3	16.6	17.4	15.2	23.1	11.3	14.7	14.2
U	4.48	2.25	3.06	3.38	3.58	3.43	3.29	7.58	2.42	3.58	3.00	2.76	5.09	2.34	2.51	2.45
ΣREE	208.79	88.51	152.09	152.09	191.99	160.07	161.43	179.96	76.83	196.08	130.13	141.88	207.99	150.69	160.92	148.07
$(La/Yb)_N$	10.38	8.10	9.50	9.12	10.08	9.60	9.25	1.49	5.80	8.93	9.51	9.66	7.75	8.00	7.00	6.95
$(La/Sm)_N$	3.74	3.85	4.07	3.93	3.84	3.84	4.00	1.22	5.76	4.80	4.33	4.09	3.87	3.61	3.81	4.18
δEu	0.43	0.75	0.57	0.49	0.58	0.57	0.52	0.06	0.62	0.53	0.36	0.51	0.36	0.74	0.59	0.50
δCe	1.01	1.00	1.00	0.98	0.97	0.98	0.99	1.00	1.04	1.04	0.94	0.91	1.00	1.00	0.99	1.00

Supplementary Materials Table S2. LA–ICP–MS zircon U–Pb age test results of Carboniferous System clastic rocks in Alake Lake area.

	Pb	^{232}Th	^{238}U	Th/U	^{207}Pb/^{206}Pb	1σ	^{207}Pb/^{235}U	1σ	^{206}Pb/^{238}U	1σ	^{207}Pb/^{206}Pb	1σ	^{207}Pb/^{235}U	1σ	^{206}Pb/^{238}U	1σ	
11121–3																	
1	232	1495	1094	1.37	0.0551	0.0018	0.5141	0.0171	0.0673	0.0007	417	72	421	12	420	4	99%
2	360	822	1209	0.68	0.0680	0.0018	1.3694	0.0346	0.1452	0.0012	878	54	876	15	874	7	99%
3	986	389	2212	0.18	0.1384	0.0029	6.8280	0.1392	0.3545	0.0025	2206	37	2089	18	1956	12	93%
4	232	1345	1213	1.11	0.0527	0.0016	0.5155	0.0155	0.0703	0.0007	322	70	422	10	438	4	96%
5	1761	1334	1729	0.77	0.1535	0.0037	9.7501	0.2147	0.4547	0.0036	2387	41	2411	20	2416	16	99%
6	477	854	1045	0.82	0.0755	0.0023	2.1134	0.0592	0.2000	0.0017	1083	61	1153	19	1176	9	98%
7	932	1959	3812	0.51	0.0738	0.0021	1.6335	0.0461	0.1579	0.0020	1036	58	983	18	945	11	96%
8	343	1662	2387	0.70	0.0543	0.0017	0.5290	0.0157	0.0697	0.0006	389	70	431	10	434	4	99%
9	717	1302	1305	1.00	0.0827	0.0020	2.5159	0.0585	0.2175	0.0017	1263	47	1277	17	1269	9	99%
10	292	458	811	0.56	0.0739	0.0021	2.0997	0.0558	0.2038	0.0017	1040	56	1149	18	1196	9	96%
11	183	400	639	0.63	0.0694	0.0022	1.4390	0.0437	0.1492	0.0012	909	66	905	18	896	7	99%
12	539	868	1114	0.78	0.0804	0.0024	2.4850	0.0704	0.2219	0.0020	1206	59	1268	21	1292	11	98%
13	539	3280	4765	0.69	0.0569	0.0018	0.5137	0.0154	0.0649	0.0006	487	67	421	10	405	4	96%
14	137	623	1038	0.60	0.0528	0.0019	0.5091	0.0181	0.0695	0.0007	317	81	418	12	433	4	96%
15	625	750	1530	0.49	0.0879	0.0020	3.0543	0.0726	0.2494	0.0025	1381	45	1421	18	1435	13	99%
16	392	1336	752	1.78	0.0688	0.0020	1.2989	0.0354	0.1360	0.0012	892	59	845	16	822	7	97%
17	521	859	727	1.18	0.0941	0.0024	3.1871	0.0773	0.2438	0.0020	1511	48	1454	19	1406	10	96%
18	373	889	968	0.92	0.0737	0.0022	1.6340	0.0454	0.1597	0.0014	1035	63	983	18	955	8	97%
19	624	2435	764	3.19	0.0677	0.0021	1.2078	0.0360	0.1289	0.0013	857	63	804	17	781	8	97%
20	2001	5590	2458	2.27	0.0725	0.0015	1.7182	0.0363	0.1705	0.0015	1011	38	1015	14	1015	8	99%
21	464	918	986	0.93	0.0793	0.0018	2.1216	0.0473	0.1923	0.0013	1181	49	1156	15	1134	7	98%
22	740	1217	749	1.63	0.0980	0.0021	3.6196	0.0759	0.2664	0.0020	1587	41	1554	17	1522	10	97%
23	111	66	672	0.10	0.0722	0.0019	1.5645	0.0408	0.1567	0.0016	991	21	956	16	938	9	98%
24	419	309	2322	0.13	0.0720	0.0017	1.6403	0.0385	0.1642	0.0014	987	48	986	15	980	8	99%
25	447	862	1442	0.60	0.0725	0.0019	1.5684	0.0401	0.1560	0.0013	1011	54	958	16	935	7	97%
26	2540	2837	3135	0.90	0.1137	0.0023	5.1963	0.1019	0.3290	0.0023	1859	31	1852	17	1834	11	99%
27	114	562	641	0.88	0.0569	0.0021	0.5713	0.0206	0.0724	0.0007	500	81	459	13	451	4	98%
28	446	625	653	0.96	0.0952	0.0021	3.5077	0.0751	0.2649	0.0018	1531	36	1529	17	1515	9	99%
29	201	413	712	0.58	0.0721	0.0020	1.5287	0.0398	0.1525	0.0012	989	56	942	16	915	7	97%
30	473	590	2127	0.28	0.0756	0.0019	1.8319	0.0441	0.1736	0.0014	1087	55	1057	16	1032	8	97%
31	616	513	861	0.60	0.1239	0.0029	6.2677	0.1406	0.3622	0.0027	2014	42	2014	20	1993	13	98%
32	616	824	771	1.07	0.1029	0.0023	4.3158	0.0926	0.3008	0.0021	1677	42	1696	18	1695	10	99%
33	470	788	1186	0.66	0.0758	0.0019	2.0375	0.0492	0.1928	0.0015	1100	50	1128	16	1136	8	99%
34	468	951	1368	0.70	0.0714	0.0018	1.6421	0.0393	0.1652	0.0012	969	52	987	15	986	7	99%
35	1379	2520	1539	1.64	0.0893	0.0020	3.1681	0.0689	0.2546	0.0019	1410	44	1449	17	1462	10	99%
36	161	380	557	0.68	0.0643	0.0020	1.2987	0.0394	0.1454	0.0017	754	67	845	17	875	9	96%
37	291	310	1549	0.20	0.0691	0.0017	1.5328	0.0361	0.1593	0.0012	902	52	944	14	953	7	99%
38	405	1971	2485	0.79	0.0549	0.0016	0.5570	0.0157	0.0731	0.0007	409	65	450	10	455	4	98%
39	554	421	701	0.60	0.1350	0.0031	7.5547	0.1628	0.4019	0.0028	2165	40	2179	19	2178	13	99%
40	174	791	1097	0.72	0.0562	0.0019	0.5743	0.0190	0.0737	0.0007	457	71	461	12	459	4	99%
41	927	1258	1607	0.78	0.0950	0.0025	3.5457	0.0881	0.2679	0.0020	1528	48	1537	20	1530	10	99%
42	502	2509	3111	0.81	0.0574	0.0018	0.5772	0.0178	0.0722	0.0007	506	70	463	11	450	4	97%
43	503	878	1876	0.47	0.0726	0.0022	1.6293	0.0466	0.1611	0.0013	1003	61	982	18	963	7	98%
44	786	873	991	0.88	0.1156	0.0029	5.2241	0.1243	0.3243	0.0024	1900	44	1857	20	1811	12	97%
45	233	602	517	1.16	0.0705	0.0021	1.5272	0.0458	0.1556	0.0014	944	63	941	18	932	8	99%
46	536	627	1589	0.39	0.0902	0.0022	2.8078	0.0842	0.2208	0.0033	1429	46	1358	22	1286	17	94%
47	2266	1391	2017	0.69	0.1827	0.0037	13.1726	0.2536	0.5171	0.0035	2677	33	2692	18	2687	15	99%
48	225	1026	1281	0.80	0.0580	0.0020	0.6174	0.0204	0.0766	0.0008	532	79	488	13	476	5	97%
49	345	453	523	0.87	0.0990	0.0026	4.0145	0.1043	0.2912	0.0027	1606	49	1637	21	1647	13	99%
50	1919	1586	3142	0.50	0.1147	0.0022	5.4425	0.1040	0.3408	0.0025	1876	35	1892	16	1891	12	99%
51	592	498	1134	0.44	0.1079	0.0020	4.7215	0.0889	0.3149	0.0024	1765	35	1771	16	1765	12	99%

52	512	1007	1502	0.67	0.0728	0.0015	1.7336	0.0355	0.1715	0.0012	1009	42	1021	13	1020	7	99%
53	320	665	773	0.86	0.0708	0.0017	1.6703	0.0386	0.1701	0.0012	954	47	997	15	1013	7	98%
54	383	761	1266	0.60	0.0714	0.0016	1.6055	0.0353	0.1625	0.0014	969	46	972	14	971	8	99%
55	362	814	824	0.99	0.0744	0.0020	1.7280	0.0456	0.1677	0.0014	1054	56	1019	17	1000	8	98%
56	189	325	637	0.51	0.0726	0.0020	1.7066	0.0446	0.1697	0.0014	1003	55	1011	17	1010	8	99%
57	2137	1553	2126	0.73	0.1583	0.0032	9.5715	0.1987	0.4348	0.0040	2439	35	2394	19	2327	18	97%
58	572	757	3322	0.23	0.0683	0.0016	1.3253	0.0290	0.1395	0.0010	876	47	857	13	842	6	98%
59	1309	1292	826	1.56	0.1612	0.0037	10.1026	0.2179	0.4504	0.0035	2468	39	2444	20	2397	16	98%
60	736	1239	2745	0.45	0.0725	0.0019	1.6425	0.0415	0.1627	0.0017	998	52	987	16	972	10	98%
61	1001	613	959	0.64	0.1563	0.0029	9.8530	0.1771	0.4557	0.0033	2416	31	2421	17	2421	14	99%
62	747	474	596	0.79	0.1628	0.0027	10.9776	0.1834	0.4868	0.0032	2487	28	2521	16	2557	14	98%
63	442	584	1601	0.36	0.0707	0.0014	1.6053	0.0311	0.1642	0.0012	950	42	972	12	980	7	99%
64	1155	64	1396	0.05	0.2275	0.0035	18.6618	0.2847	0.5919	0.0036	3035	26	3024	15	2997	14	99%
65	433	348	550	0.63	0.1179	0.0023	5.6060	0.1109	0.3434	0.0031	1926	31	1917	17	1903	15	99%
66	112	488	735	0.66	0.0537	0.0019	0.4982	0.0173	0.0670	0.0007	367	78	410	12	418	4	98%
67	1175	792	886	0.89	0.1644	0.0033	10.8336	0.2080	0.4752	0.0033	2502	33	2509	18	2506	15	99%
68	837	992	1490	0.67	0.0883	0.0016	2.9615	0.0554	0.2417	0.0018	1391	36	1398	14	1395	9	99%
69	180	706	1048	0.67	0.0545	0.0015	0.5502	0.0148	0.0730	0.0006	391	63	445	10	454	3	98%
70	484	39	2346	0.02	0.0785	0.0013	2.1687	0.0345	0.1992	0.0011	1161	31	1171	11	1171	6	99%
71	575	561	636	0.88	0.1125	0.0020	5.0583	0.0837	0.3248	0.0020	1840	31	1829	14	1813	10	99%
72	410	469	1080	0.43	0.0813	0.0016	2.4193	0.0470	0.2147	0.0016	1229	38	1248	14	1254	9	99%
73	263	1210	1582	0.76	0.0552	0.0014	0.5272	0.0128	0.0691	0.0005	420	56	430	9	431	3	99%
74	1311	1275	1220	1.05	0.1159	0.0019	5.5101	0.0872	0.3433	0.0019	1894	30	1902	14	1902	9	99%
75	335	82	2153	0.04	0.0696	0.0011	1.3802	0.0226	0.1432	0.0008	917	34	881	10	863	5	97%
76	593	736	2218	0.33	0.0707	0.0012	1.6129	0.0277	0.1649	0.0010	948	31	975	11	984	6	99%
77	432	706	841	0.84	0.0790	0.0015	2.1417	0.0411	0.1963	0.0011	1172	39	1162	13	1155	6	99%
78	284	415	952	0.44	0.0728	0.0015	1.6826	0.0348	0.1673	0.0011	1009	42	1002	13	997	6	99%
79	1786	1984	1914	1.04	0.1074	0.0018	4.7516	0.0828	0.3202	0.0021	1755	31	1776	15	1791	10	99%
80	330	556	616	0.90	0.0794	0.0015	2.2102	0.0421	0.2017	0.0013	1183	39	1184	13	1184	7	99%

11085–12

1	317	1655	1858	0.89	0.0566	0.0018	0.5771	0.0183	0.0741	0.0008	476	70	463	12	461	5	99%
2	324	246	468	0.53	0.1370	0.0033	7.0693	0.1718	0.3738	0.0030	2191	42	2120	22	2047	14	96%
4	115	193	367	0.53	0.0764	0.0027	1.8547	0.0644	0.1766	0.0020	1106	70	1065	23	1048	11	98%
5	242	1161	1872	0.62	0.0572	0.0016	0.5356	0.0147	0.0679	0.0006	502	63	436	10	424	3	97%
6	577	1520	997	1.52	0.0732	0.0017	1.7407	0.0403	0.1720	0.0012	1020	46	1024	15	1023	7	99%
7	192	1159	768	1.51	0.0569	0.0021	0.5846	0.0216	0.0743	0.0007	487	81	467	14	462	4	98%
8	252	1571	1334	1.18	0.0558	0.0017	0.5283	0.0162	0.0684	0.0006	443	69	431	11	427	4	99%
9	285	1501	1887	0.80	0.0605	0.0019	0.5684	0.0177	0.0678	0.0007	620	69	457	11	423	4	92%
10	246	1309	1647	0.79	0.0565	0.0016	0.5387	0.0145	0.0689	0.0006	472	61	438	10	430	4	98%
11	251	1580	1321	1.20	0.0555	0.0018	0.5273	0.0161	0.0687	0.0007	432	70	430	11	428	4	99%
12	219	512	633	0.81	0.0719	0.0024	1.5821	0.0520	0.1583	0.0017	983	69	963	20	947	9	98%
13	358	1686	2315	0.73	0.0576	0.0019	0.5832	0.0192	0.0728	0.0008	517	74	466	12	453	5	97%
14	192	949	1375	0.69	0.0553	0.0019	0.5366	0.0181	0.0697	0.0007	433	76	436	12	434	4	99%
15	1007	816	923	0.88	0.1582	0.0037	10.1044	0.2361	0.4590	0.0039	2437	40	2444	22	2435	17	99%
16	1379	1459	2017	0.72	0.1335	0.0030	5.5666	0.1245	0.3001	0.0029	2146	39	1911	19	1692	15	87%
17	249	1225	1304	0.94	0.0600	0.0023	0.6102	0.0234	0.0733	0.0008	603	85	484	15	456	5	94%
18	275	1140	2264	0.50	0.0564	0.0017	0.5651	0.0168	0.0724	0.0008	465	101	455	11	451	5	99%
19	197	872	1595	0.55	0.0575	0.0019	0.5651	0.0172	0.0711	0.0008	522	75	455	11	443	5	97%
20	311	1689	1745	0.97	0.0563	0.0017	0.5585	0.0168	0.0717	0.0007	465	69	451	11	446	4	99%
21	216	1204	1219	0.99	0.0568	0.0021	0.5488	0.0190	0.0700	0.0007	483	47	444	12	436	4	98%
22	476	2590	3086	0.84	0.0565	0.0017	0.5383	0.0161	0.0688	0.0006	478	67	437	11	429	4	98%
23	434	284	461	0.62	0.1705	0.0045	11.3441	0.2968	0.4807	0.0050	2562	44	2552	24	2530	22	99%
24	456	321	968	0.33	0.1163	0.0034	5.1593	0.1507	0.3204	0.0038	1900	52	1846	25	1792	18	97%
25	614	616	999	0.62	0.1171	0.0036	5.2638	0.1641	0.3245	0.0037	1922	56	1863	27	1812	18	97%
26	106	512	681	0.75	0.0570	0.0025	0.5737	0.0243	0.0733	0.0010	494	98	460	16	456	6	99%
27	248	947	2431	0.39	0.0576	0.0018	0.5395	0.0162	0.0677	0.0007	517	63	438	11	422	4	96%
28	176	787	1283	0.61	0.0624	0.0025	0.5993	0.0242	0.0694	0.0008	687	86	477	15	433	5	90%

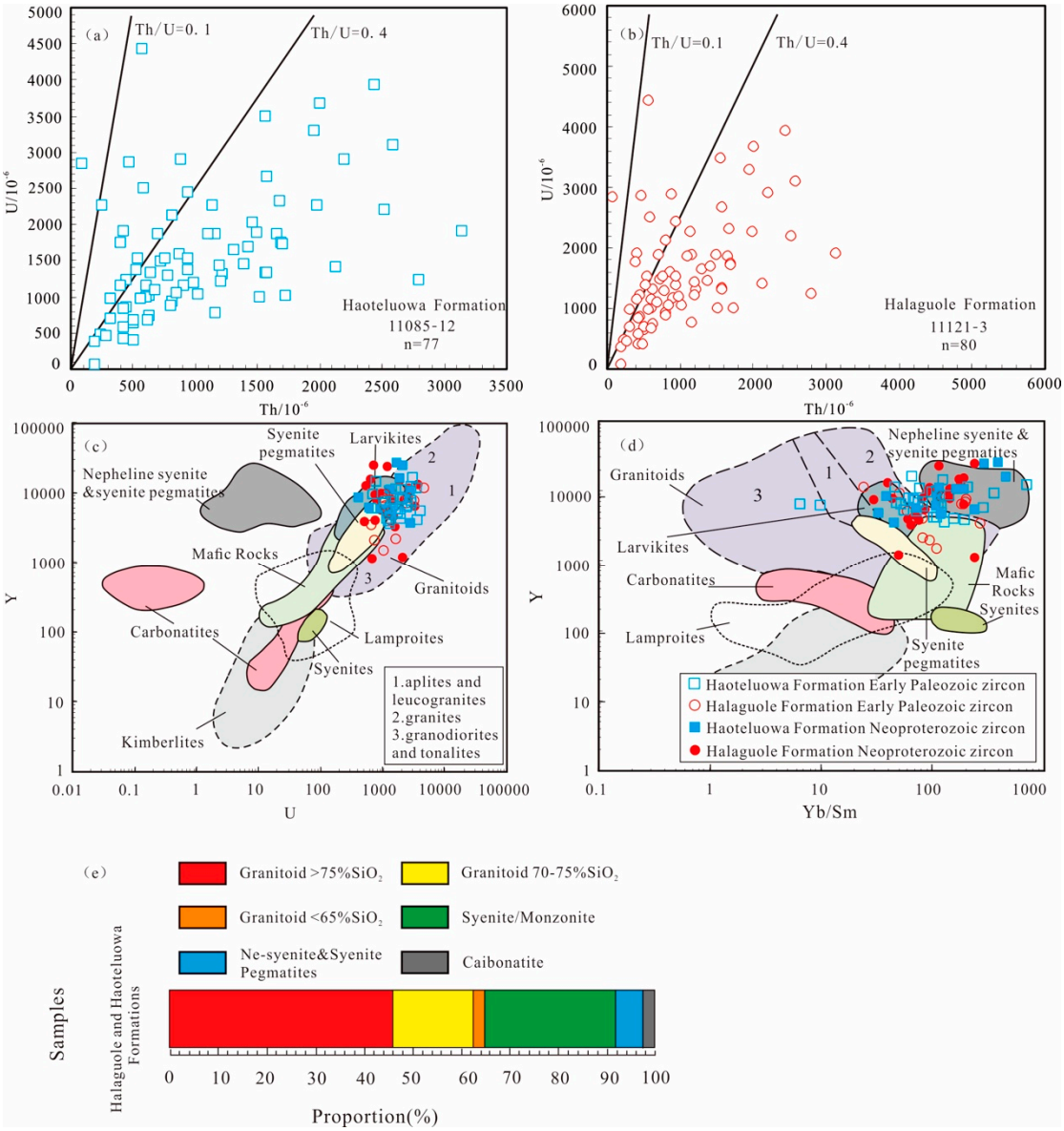
29	717	730	1483	0.49	0.1113	0.0024	4.3722	0.0947	0.2837	0.0024	1820	41	1707	18	1610	12	94%
30	735	907	1156	0.78	0.1060	0.0024	4.3369	0.1000	0.2951	0.0024	1732	43	1700	19	1667	12	98%
31	471	1199	1419	0.85	0.0709	0.0018	1.4954	0.0381	0.1521	0.0012	955	54	929	16	913	7	98%
32	847	1023	1039	0.98	0.1159	0.0024	5.3050	0.1095	0.3299	0.0024	1894	38	1870	18	1838	12	98%
33	206.3	86.4	2844	0.03	0.0570	0.0014	0.6430	0.0155	0.0812	0.0006	500	52	504	10	503	4	99%
34	1093	762	1534	0.50	0.1371	0.0027	7.4415	0.1461	0.3903	0.0033	2191	29	2166	18	2124	15	98%
35	560	473	2852	0.17	0.0716	0.0016	1.6468	0.0355	0.1655	0.0013	974	45	988	14	987	7	99%
36	158	430	409	1.05	0.0666	0.0023	1.4250	0.0473	0.1541	0.0017	828	72	899	20	924	10	97%
37	457	704	1871	0.38	0.0698	0.0016	1.6331	0.0372	0.1682	0.0014	920	48	983	14	1002	8	98%
38	431	1959	3291	0.60	0.0555	0.0014	0.5460	0.0136	0.0707	0.0006	432	56	442	9	440	3	99%
39	438	450	859	0.52	0.0941	0.0021	3.9104	0.0832	0.2995	0.0023	1510	9	1616	17	1689	11	95%
40	224	503	395	1.27	0.0708	0.0022	1.9412	0.0610	0.1977	0.0019	952	64	1095	21	1163	10	94%
41	71	201	61.7	3.25	0.0790	0.0041	2.1139	0.1080	0.1953	0.0031	1172	69	1153	35	1150	17	99%
42	1920	1706	1724	0.99	0.1438	0.0033	8.8956	0.2153	0.4464	0.0049	2273	45	2327	22	2379	22	97%
43	1099	851	1046	0.81	0.1541	0.0035	10.1060	0.2321	0.4736	0.0040	2392	38	2445	21	2499	18	97%
44	611	2446	3923	0.62	0.0529	0.0013	0.5855	0.0147	0.0801	0.0007	324	62	468	9	497	4	94%
45	299	448	1223	0.37	0.0700	0.0017	1.6210	0.0409	0.1671	0.0014	928	56	978	16	996	8	98%
46	422	2201	2906	0.76	0.0542	0.0013	0.5253	0.0124	0.0701	0.0006	389	56	429	8	437	3	98%
47	251	1110	1863	0.60	0.0569	0.0016	0.5586	0.0159	0.0710	0.0006	487	58	451	10	442	4	98%
48	352	641	1321	0.49	0.0713	0.0018	1.6123	0.0413	0.1631	0.0013	969	49	975	16	974	7	99%
49	480	639	735	0.87	0.1031	0.0025	4.1862	0.0982	0.2931	0.0024	1681	44	1671	19	1657	12	99%
50	597	425	574	0.74	0.1700	0.0035	11.4834	0.2384	0.4872	0.0039	2558	34	2563	19	2559	17	99%
51	383	424	1901	0.22	0.0718	0.0016	1.6459	0.0358	0.1654	0.0012	989	17	988	14	987	6	99%
52	2041	1430	1692	0.84	0.1659	0.0032	11.6971	0.2345	0.5088	0.0042	2516	33	2580	19	2652	18	97%
53	3006	2526	2202	1.15	0.1693	0.0035	11.4266	0.2426	0.4870	0.0038	2550	34	2559	20	2558	16	99%
54	435	319	687	0.46	0.1330	0.0035	7.1527	0.1996	0.3874	0.0042	2139	46	2131	25	2111	20	99%
55	246	1727	1003	1.72	0.0583	0.0022	0.5437	0.0199	0.0675	0.0008	543	88	441	13	421	5	95%
56	396	543	1535	0.35	0.0773	0.0019	1.9545	0.0475	0.1823	0.0016	1129	48	1100	16	1079	9	98%
57	382	2128	1412	1.51	0.0626	0.0020	0.6968	0.0225	0.0801	0.0009	694	67	537	13	497	5	92%
58	120	619	670	0.92	0.0566	0.0022	0.5949	0.0223	0.0761	0.0008	476	90	474	14	473	5	99%
59	571	406	1155	0.35	0.1178	0.0030	5.4740	0.1407	0.3344	0.0033	1924	46	1897	22	1860	16	98%
60	1073	1391	1457	0.95	0.1101	0.0028	4.7621	0.1199	0.3109	0.0026	1802	47	1778	21	1745	13	98%
61	338	524	1377	0.38	0.0703	0.0020	1.6019	0.0430	0.1642	0.0016	939	57	971	17	980	9	99%
62	145	614	1144	0.54	0.0557	0.0022	0.5477	0.0216	0.0710	0.0010	439	87	444	14	442	6	99%
63	373	1984	2258	0.88	0.0540	0.0015	0.5293	0.0149	0.0706	0.0006	372	63	431	10	440	4	98%
64	149	683	1088	0.63	0.0558	0.0021	0.5516	0.0203	0.0715	0.0008	456	81	446	13	445	5	99%
65	953	2802	1232	2.28	0.0681	0.0017	1.5748	0.0378	0.1671	0.0015	872	51	960	15	996	8	96%
66	256	567	978	0.58	0.0627	0.0018	1.2183	0.0348	0.1404	0.0013	698	62	809	16	847	8	95%
67	483	815	2119	0.38	0.0654	0.0016	1.3964	0.0348	0.1539	0.0012	787	47	887	15	923	7	96%
68	511	584	2507	0.23	0.0695	0.0015	1.5879	0.0355	0.1648	0.0014	922	50	965	14	983	8	98%
69	1342	2005	3672	0.55	0.0802	0.0017	2.2494	0.0452	0.2021	0.0014	1267	41	1197	14	1187	8	99%
70	995	577	4426	0.13	0.0792	0.0018	2.2319	0.0487	0.2029	0.0016	1177	44	1191	15	1191	9	99%
71	592	886	2887	0.31	0.0741	0.0020	1.6770	0.0436	0.1628	0.0016	1056	54	1000	17	973	9	97%
72	203	945	1522	0.62	0.0572	0.0025	0.5461	0.0222	0.0689	0.0007	502	64	442	15	429	4	97%
73	765	251	2268	0.11	0.1277	0.0037	5.0646	0.1498	0.2838	0.0029	2078	50	1830	25	1610	15	87%
74	362	1575	2657	0.59	0.0602	0.0019	0.5903	0.0183	0.0706	0.0007	609	69	471	12	440	4	93%
75	3001	3147	1907	1.65	0.1628	0.0035	9.8547	0.2085	0.4350	0.0033	2485	36	2421	20	2328	15	96%
76	393	807	872	0.93	0.0769	0.0018	1.9913	0.0446	0.1867	0.0015	1120	46	1113	15	1103	8	99%
77	416	424	828	0.51	0.1034	0.0023	4.1214	0.0872	0.2871	0.0025	1687	36	1659	17	1627	13	98%
78	279	398	1751	0.23	0.0653	0.0018	1.1822	0.0309	0.1307	0.0015	783	59	792	14	792	9	99%
79	496	993	1200	0.83	0.0747	0.0018	1.8777	0.0445	0.1810	0.0015	1061	49	1073	16	1073	8	99%

Supplementary Materials Table S3. Geochemical comparison of four measured sections of the Carboniferous in Alake Lake area.

	C_2-P_1Haoteluowa Fm		C_1Halaguole Fm	
	Naomuhunyamatuo	Haganuoer	Xilikete	Helegangxilikete
$100*TiO_2/Al_2O_3$	3.35	2.3	3.54	1.03
$100*TiO_2/Fe_2O_3T$	13.08	10.76	12.61	14.1
Al_2O_3/TiO_2	37.83	43.44	39.06	97.08
$(La/Yb)_N$	8.47	6.95	8.44	5.8
Eu/Eu*	0.52	0.5	0.5	0.61
La/Sc	4.64	6	4	5.16
Th/Sc	2.3	2.75	2.18	4.91
La/Th	2.18	2.18	2.01	1.05
Zr/Sc	25.57	23.98	29	24.39
Th/Sc	2.30	2.75	2.18	4.91

Supplementary Materials Table S4. Statistics of sandstone clastic components of the Carboniferous in Alake Lake area.

Number	Sample	Formation	Section	Qm	Qp	Qt	F	Pl	K	Lv	Lm	Ls	L	Lt	Total
1	11085–12	Haoteluowa Fm.	Naomuhunyamatu	272	31	303	31	20	11	32	20	33	85	116	419
2	11086–4	Haoteluowa Fm.	Naomuhunyamatu	159	26	185	98	63	35	65	70	23	158	184	441
3	11086–5	Haoteluowa Fm.	Naomuhunyamatu	106	21	127	118	80	38	78	70	21	169	190	414
4	11086–9	Haoteluowa Fm.	Naomuhunyamatu	147	21	168	121	78	43	57	64	34	155	176	444
5	11086–12	Haoteluowa Fm.	Naomuhunyamatu	207	8	215	81	53	28	53	44	16	113	121	409
6	11086–10	Haoteluowa Fm.	Naomuhunyamatu	190	11	201	53	37	16	77	16	65	158	169	412
7	11086–7	Haoteluowa Fm.	Naomuhunyamatu	201	14	215	117	80	37	89	13	8	110	124	441
8	11086–13	Haoteluowa Fm.	Naomuhunyamatu	226	14	240	73	51	22	66	21	22	109	123	422
9	11099–4	Haoteluowa Fm.	Haganuoer	262	9	271	64	44	20	37	22	44	103	112	438
	mean value (%)	Haoteluowa Fm.		46	4	50	20	13	7	14	7	9	30	34	100
10	11091–12	Halaguole Fm.	Xilikete	209	25	234	82	56	26	33	42	53	128	153	444
11	11091–13	Halaguole Fm.	Xilikete	239	39	278	78	49	29	31	25	22	78	117	434
12	11091–19	Halaguole Fm.	Xilikete	211	36	247	68	47	21	61	30	20	111	147	426
13	11091–14	Halaguole Fm.	Xilikete	202	28	230	56	38	18	35	42	56	133	161	419
14	11091–20	Halaguole Fm.	Xilikete	212	30	242	62	45	17	63	19	53	135	165	439
15	11091–15	Halaguole Fm.	Xilikete	195	24	219	81	52	29	39	36	40	115	139	415
16	11121–6	Halaguole Fm.	Helegangxilikete	410	8	418	1	1	0	2	0	1	3	11	422
17	11121–7	Halaguole Fm.	Helegangxilikete	394	30	424	4	3	1	2	1	4	7	37	435
	mean value (%)	Halaguole Fm.		60	7	67	12	8	4	8	6	7	21	27	100



Supplementary Materials Figure S1. Trace element characteristics of the detrital zircons from the Halaguole and Haoteluowa formations. (a) (b)U–Th diagram（modified from [46]; (c)Y–U diagram（modified from [62]; (d)Y-Yb/Sm diagram (modified from [62]); (e) Results of classication and regression tree (CART) analysis (modified from [62]), showing the proportion of zircon grains from different rock types in the total detrital zircons; the ordinate displays the sample name. “Granitoids” include: 1 aplites and leucogranites; 2 granites; 3 granodiorites and tonalite.

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