minerals

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Supplementary Materials

Petrogenesis and Geological Implications of the Oligocene Mingze monzodiorites, Southern Lhasa

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Table S1. LA–ICP–MS zircon U–Pb age data for the Mingze monzodiorites.

Analysis	content (ppm)			Th/U	Isotope Ratios						Age (Ma)					
	Th	U	Pb		$^{207}Pb/^{206}Pb$	σ	$^{207}Pb/^{235}U$	σ	$^{206}Pb/^{238}U$	σ	$^{207}Pb/^{206}Pb$	σ	$^{207}Pb/^{235}U$	σ	$^{206}Pb/^{238}U$	σ
1	1548.44	1113.26	18.79	1.39	0.046007	0.0025	0.032590	0.0017	0.005084	0.00008	-	-	32.56	1.72	32.69	0.51
2	1222.62	2391.54	0.00	0.51	0.047851	0.0019	0.031680	0.0012	0.004814	0.00006	100.09	87.03	31.67	1.19	30.96	0.37
3	896.05	793.56	0.00	1.13	0.047664	0.0028	0.032143	0.0019	0.004892	0.00009	83.43	133.32	32.12	1.82	31.46	0.56
4	526.88	957.88	6.44	0.55	0.046855	0.0029	0.029706	0.0017	0.004638	0.00008	42.69	140.73	29.72	1.67	29.83	0.51
5	408.45	1024.29	36.91	0.40	0.056805	0.0032	0.039621	0.0021	0.005141	0.00010	483.38	122.21	39.45	2.01	33.06	0.63
6	1222.93	1211.93	71.78	1.01	0.047420	0.0026	0.032223	0.0016	0.004962	0.00008	77.87	120.36	32.20	1.58	31.91	0.53
7	456.98	731.53	0.00	0.62	0.047654	0.0042	0.032478	0.0027	0.005031	0.00010	83.43	196.27	32.45	2.67	32.35	0.64
8	1063.96	724.62	26.66	1.47	0.052457	0.0056	0.034452	0.0031	0.005044	0.00012	305.62	244.42	34.39	3.01	32.43	0.76
9	933.19	1075.50	0.00	0.87	0.054848	0.0034	0.034532	0.0022	0.004533	0.00010	405.61	138.88	34.47	2.15	29.16	0.62

10	2722.47	2636.89	31.40	1.03	0.046100	0.0018	0.030418	0.0012	0.004768	0.00006	400.05	-305.5	30.43	1.18	30.67	0.38
11	1576.67	2604.80	101.23	0.61	0.046073	0.0015	0.031693	0.0011	0.004958	0.00006	400.05	-320.3	31.68	1.04	31.88	0.37
12	1238.02	1640.87	0.00	0.75	0.061973	0.0033	0.038117	0.0022	0.004445	0.00010	672.24	114.80	37.98	2.15	28.59	0.65
13	4691.71	2644.57	67.14	1.77	0.050046	0.0022	0.031440	0.0014	0.004547	0.00007	198.23	97.21	31.43	1.37	29.25	0.43
14	4184.12	3130.71	59.73	1.34	0.049790	0.0022	0.033258	0.0013	0.004874	0.00006	183.42	101.84	33.22	1.27	31.34	0.41
16	713.78	1216.18	0.00	0.59	0.048734	0.0025	0.033745	0.0017	0.005111	0.00009	200.08	120.35	33.70	1.67	32.86	0.60
17	902.35	752.65	0.00	1.20	0.047520	0.0037	0.029834	0.0022	0.004663	0.00009	76.02	174.05	29.85	2.16	29.99	0.61
18	4140.73	3925.15	37.50	1.05	0.047083	0.0016	0.034705	0.0012	0.005339	0.00007	53.80	77.77	34.64	1.18	34.33	0.43
19	583.54	1345.07	0.00	0.43	0.047268	0.0027	0.030458	0.0016	0.004754	0.00007	61.21	129.62	30.47	1.56	30.57	0.44
20	1247.60	1712.99	0.00	0.73	0.045937	0.0025	0.030543	0.0017	0.004844	0.00009	-	-	30.55	1.70	31.15	0.59
21	593.75	561.86	23.54	1.06	0.048357	0.0054	0.030157	0.0030	0.004701	0.00013	116.76	249.97	30.17	2.93	30.23	0.80
22	1904.25	2654.40	52.24	0.72	0.055132	0.0025	0.038563	0.0017	0.005070	0.00006	416.72	99.99	38.42	1.63	32.60	0.41
23	980.91	552.53	20.07	1.78	0.047485	0.0041	0.030948	0.0024	0.004851	0.00010	72.32	192.57	30.95	2.38	31.20	0.66
24	796.03	1132.39	0.00	0.70	0.046970	0.0025	0.030648	0.0016	0.004775	0.00008	55.65	112.95	30.65	1.59	30.71	0.52
25	700.24	938.18	0.00	0.75	0.048081	0.0037	0.034331	0.0025	0.005300	0.00010	101.94	174.05	34.27	2.42	34.07	0.66
15	~~1211.60~~	~~1101.78~~	~~77.34~~	~~1.10~~	~~0.150832~~	~~0.0126~~	~~0.130001~~	~~0.0143~~	~~0.005614~~	~~0.00015~~	~~2355.25~~	~~143.21~~	~~124.10~~	~~12.85~~	~~36.09~~	~~0.10~~

Table S2. In-situ zircon Hf isotopic data of for the Mingze gabbro diorites.

Analysis	$^{176}Yb/^{177}Hf$	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	εHf (t)	T_{DM1}	T_{DM2}	$f_{Lu/Hf}$
1	0.022356	0.000499	0.282912	5.645844	475.7617	750.1012	-0.98498
2	0.032066	0.000833	0.282951	6.99447	424.3153	662.2649	-0.97492
3	0.05397	0.001153	0.282957	7.211648	419.3617	648.7006	-0.96527
4	0.016199	0.00044	0.282866	3.967777	538.9164	855.4029	-0.98674
6	0.034622	0.000759	0.282886	4.699	515.8645	810.1398	-0.97714
7	0.017513	0.000518	0.282953	7.093727	418.3196	656.9865	-0.9844
8	0.057058	0.001259	0.282921	5.961389	471.8216	729.6173	-0.96209
10	0.031514	0.000797	0.282948	6.878868	428.3102	669.4605	-0.976
11	0.034991	0.001001	0.282874	4.281806	535.6843	836.8144	-0.96985
13	0.020856	0.00053	0.282871	4.12119	533.5503	845.1287	-0.98404
14	0.023062	0.000595	0.282964	7.459275	403.7136	632.7509	-0.98209
16	0.083558	0.002016	0.282933	6.357111	464.9707	704.5255	-0.93929
17	0.036814	0.000817	0.282796	1.495164	642.614	1013.621	-0.97541
18	0.059191	0.001477	0.282865	4.011583	555.1834	855.9307	-0.95552
19	0.020072	0.00048	0.282946	6.83094	426.8214	672.4822	-0.98553
20	0.011213	0.000273	0.282913	5.680967	470.4432	746.6868	-0.99179
21	0.030307	0.00067	0.282821	2.389576	604.9895	956.6594	-0.97982
22	0.007383	0.000194	0.282959	7.335265	405.7843	641.7002	-0.99415
23	0.020113	0.000534	0.282839	3.028263	578.4985	916.562	-0.98393
24	0.027526	0.00072	0.282891	4.876806	507.273	797.8398	-0.97831
25	0.031544	0.000724	0.282875	4.384911	529.7668	831.9178	-0.97819

Table S3. Major (wt.%), trace element (ppm) and Sr–Nd isotopic composition of the Mingze monzodiorites.

Sample	MZ07	MZ07'	MZ08	MZ15-1	MZ15-2	MZ15-3	MZ15-4
Major element(wt.%)							
Al_2O_3	16.53	16.78	15.97	16.43	17.31	17.04	16.05
$^{T}Fe_2O_3$	5.79	5.40	3.94	7.00	4.68	7.67	7.78
^{T}FeO	5.21	4.86	3.54	6.30	4.21	6.90	7.00
K_2O	4.01	4.07	4.29	3.45	3.18	3.36	3.06
MgO	3.09	2.74	1.86	4.82	4.50	4.96	5.76
MnO	0.08	0.08	0.06	0.10	0.09	0.11	0.10
Na_2O	4.10	4.24	4.20	3.76	3.98	3.85	3.80
P_2O_5	0.51	0.42	0.28	0.67	0.77	0.68	0.89
SiO_2	58.88	60.14	64.98	54.54	54.74	54.86	52.70
TiO_2	0.67	0.60	0.48	0.94	0.94	0.88	1.10

Sample	MZ07	MZ07'	MZ08	MZ15-1	MZ15-2	MZ15-3	MZ15-4
LOI	0.69	0.65	0.56	0.77	0.98	0.47	0.97
CaO	5.47	5.15	3.27	6.65	8.62	6.26	7.16
Total	99.83	100.28	99.89	99.14	99.81	100.14	99.36
Alkaline	8.11	8.31	8.49	7.21	7.16	7.21	6.86
A/NK	1.49	1.47	1.38	1.66	1.73	1.71	1.68
A/CNK	0.79	0.81	0.91	0.75	0.67	0.80	0.71
Mg#	51.44	50.14	48.39	57.72	65.58	56.16	59.49
trace element (ppm)							
La	80.1	64.4	88.2	46.9	72.2	46.1	65.6
Ce	158.5	123.5	165	102.5	137.5	103	135
Pr	17.25	13.35	16.43	12.17	15.3	12.01	15.8
Nd	57.2	48	53.3	46.7	57.3	45.6	59.6
Sm	9.44	8.24	7.54	8.08	9.71	7.74	10.05
Eu	2.08	1.69	1.45	1.78	2.13	1.75	2.32
Gd	6.37	5.45	5.05	5.9	6.41	5.6	6.72
Tb	0.8	0.71	0.61	0.72	0.81	0.65	0.83
Dy	3.78	3.42	2.52	3.33	4.12	3.04	4.29
Ho	0.73	0.62	0.42	0.59	0.72	0.52	0.75
Er	1.83	1.65	1.16	1.6	1.96	1.41	1.98
Tm	0.26	0.23	0.15	0.22	0.27	0.18	0.27
Yb	1.66	1.42	1.06	1.38	1.68	1.15	1.72
Lu	0.28	0.19	0.16	0.21	0.24	0.18	0.24
Y	20.6	16	12	16.2	19.2	14.3	19.3
Rb	168.5	152	166	126.5	191	123.5	141
Ba	1440	1500	950	1260	1060	1460	1330
Th	47.8	54.2	80.4	22.3	28.5	21.2	29.3
U	8.71	7.84	6.5	4.3	6.66	3.7	5.29
Nb	22	17.5	23.8	16.6	14.2	15.7	15.4
Ta	1.9	1.5	1.81	1.01	0.9	1	1
Sr	1085	1040	867	1270	1305	1295	1205
Zr	247	269	71	75	199	80	158
Hf	5.9	6.6	2	2.1	5.4	2.1	4.7
Cr	70	190	32	70	140	76	160
ΣREE	340.28	272.87	343.05	232.08	310.35	228.93	305.17
LREE:HREE	20.66	18.93	29.82	15.64	18.15	16.98	17.16
(La:Yb)N	32.53	30.58	56.10	22.91	28.97	27.03	25.71
δEu	0.78	0.73	0.68	0.75	0.78	0.78	0.81

Sample	MZ07	MZ07'	MZ08	MZ15-1	MZ15-2	MZ15-3	MZ15-4
δCe	0.98	0.96	0.97	1.01	0.95	1.03	0.98
$^{87}Rb/^{86}Sr$	0.449234	0.030847	0.041625		0.28813		0.3385
$^{87}Sr/^{86}Sr$	0.707148	0.706637	0.706696		0.707143		0.707714
±2σ	0.000008	0.000009	0.000006		0.000008		0.000006
$(^{87}Sr/^{86}Sr)_i$	0.706947	0.706623	0.706678		0.707015		0.707563
$^{147}Sm/^{144}Nd$	0.099723	0.099762	0.093908		0.104548		0.102564
$^{143}Nd/^{144}Nd$	0.512411	0.512415	0.512424		0.512491		0.512436
±2σ	0.000006	0.000007	0.000006		0.000006		0.000009
$(^{143}Nd/^{144}Nd)_i$	0.512391	0.512394	0.512405		0.51247		0.512415
εNd(t)	-4.039878	-3.971754	-3.766871		-2.490726		-3.567451
T_{DM} (Ma)	990.4019	986.0666	926.1794		922.0579		981.7306