Yue Qi, Qiang Wang, Gang-Jian Wei, Xiu-Zheng Zhang, Wei Dan, Lu-Lu Hao, and Ya-Nan Yang, 2021, Late Eocene post-collisional magmatic rocks from the southern Qiangtang terrane record the melting of pre-collisional enriched lithospheric mantle: GSA Bulletin, <https://doi.org/10.1130/B35864.1>.

Supplemental Material

TEXT S1. Analytical methods including Zircon U-Pb dating and whole rock geochemistry.

TABLE S1. Zircon U-Pb isotopic data of the Baishagang, Yibuchaka, Zougouyouchacuo, and Jianshan volcanic rocks.

TABLE S2. Whole rock major and trace elements compositions and Sr-Nd isotopic ratios of the Baishagang, Yibuchaka, Zougouyouchacuo, and Jianshan volcanic rocks.

TABLE S3. The assimilation and fractional crystallization (AFC) for Late Eocene post-collisional magmatic rocks in the southern Qiangtang terrane

TABLE S4. Estimated pressure and temperature of partial melting condition

FIGURE S1. Th versus Rb, Sr, Ba, La, Hf and Cs for the Baishagang basalts

TEXT S1. ANALYTICAL METHODS

Zircon U-Pb dating

Zircon grains were casted in the epoxy mount and polished to about half their thickness for analysis. Cathodoluminescence images of zircons were conducted at the State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (SKLaBIG GIG CAS). Zircon U-Pb analyses were conducted using a CAMECAIMS-1280-HR SIMS at the SKLaBIG GIG CAS and analytical procedures is described by [Li et al. \(2009\)](#). The ellipsoidal spot is about $20\mu\text{m} \times 30\mu\text{m}$ in size. The aperture illumination mode (Kohler illumination) was used with a $200\mu\text{m}$ primary beam mass filter (PBMF) aperture to produce even sputtering over the entire analyzed area. Oxygen flooding was used to increase the O_2 pressure to 5×10^{-6} Torr in the sample chamber, enhancing Pb^+ sensitivity to a value of $\sim 25\text{cps/nA/ppm}$ for zircon. This great enhancement of Pb^+ sensitivity is crucial to improve precision of $^{207}\text{Pb}/^{206}\text{Pb}$ zircon measurement. Positive secondary ions were extracted with a 10 kV potential. In the secondary ion beam optics, a $60 \pm 5\text{eV}$ energy window was used, together with a mass resolution of ~ 5400 . Rectangular lenses were activated in the secondary ion optics to increase the transmission at high mass resolution. A single electron multiplier was used in ion-counting mode to measure secondary ion beam intensities by the peak jumping sequence: 196 ($^{90}\text{Zr}_2^{16}\text{O}$, matrix reference), 200 ($^{92}\text{Zr}_2^{16}\text{O}$), 200.5 (background), 203.81 ($^{94}\text{Zr}_2^{16}\text{O}$, for mass calibration), 203.97 (Pb), 206 (Pb), 207 (Pb), 208 (Pb), 209 ($^{177}\text{Hf}^{16}\text{O}_2$), 238 (U), 248 ($^{232}\text{Th}^{16}\text{O}$), 270 ($^{238}\text{U}^{16}\text{O}_2$), and 270.1 (reference mass). The integration time, for these mass are 1.04, 0.56, 4.16, 0.56, 6.24, 4.16, 6.24, 2.08, 1.04, 2.08, 2.08, 2.08, and 0.24 s, respectively. Each measurement consisted of seven cycles, and the total analytical time per measurement was ~ 12 minutes. Calibration of Pb/U ratios is relative to the standard zircon Plesovice (337.13 Ma, [Slama et al., 2008](#)), which was analyzed once every four unknowns, based on an observed linear relationship between $\ln(^{206}\text{Pb}/^{238}\text{U})$ and $\ln(^{238}\text{U}^{16}\text{O}_2/^{238}\text{U})$ ([Whitehouse et al., 1997](#)). A long-term uncertainty of 1.5% (1RSD) for $^{206}\text{Pb}/^{238}\text{U}$ measurements of the standard zircons was propagated to the unknowns ([Li et al., 2010](#)), despite that the measured $^{206}\text{Pb}/^{238}\text{U}$ error in a specific session is generally around 1% (1 RSD) or less. U and Th concentrations of unknowns were also calibrated relative to the standard zircon Plesovice, with Th and U concentrations of 78 and 755 ppm, respectively ([Slama et al., 2008](#)). Measured compositions were corrected for common Pb using non-radiogenic ^{204}Pb . A secondary standard zircon Qinghu ([Li et al., 2013](#)) were analyzed as unknown to monitor the reliability of the whole procedure. Uncertainties on single analyses are reported at the 1σ level; mean ages for pooled U-Pb analyses are quoted with a 95% confidence interval. Data reduction was carried out using the Isoplot/Ex 3 software ([Ludwig, 2003](#)).

Whole rock geochemistry

Whole rock major and trace elements were analyzed at SKLaBIG GIG CAS. Major-element oxides were analyzed using a Rigaku RIX 2000 X-ray and analytical uncertainties are between 1% and 5%. Trace elements were analyzed by inductively coupled

plasma mass spectrometry (ICP-MS), using a Perkin-Elmer Sciex ELAN 6000 instrument and repeated runs give 3% RSD (relative standard deviation) for most elements of reference materials analyzed by ICP-MS.

Separation and purification of the Sr-Nd isotope were performed at SKLaBIG GIG CAS. Sr and Nd isotopic ratios of selected samples were determined using a Micromass Isoprobe multi-collector mass spectrometer (MC-ICP-MS) at SKLaBIG GIG-CAS. Analytical procedures are similar to those described in Li et al., (2004). Measured $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ ratios were normalized to $^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$ and $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$, respectively. Analyses of NBS-SRM 987 and the Shin Etsu JNdi-1 standards during this study yielded an average values of $^{87}\text{Sr}/^{86}\text{Sr} = 0.710250 \pm 9$ (n=10) and $^{143}\text{Nd}/^{144}\text{Nd} = 0.512115 \pm 5$ (n=10).

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TABLE S1. Zircon U-Pb isotopic data of the Baishagang, Yibuchaka, Zougouyouchacuo, and Jianshan volcanic rocks.

Samples	[U] ppm	[Th] ppm	[Pb] ppm	Th/U	$\frac{^{238}\text{U}}{^{206}\text{Pb}}$	$\pm\sigma$ %	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	$\pm\sigma$ %	207-corr age (Ma)	$\pm\sigma$
Baishagang										
15QT46-5@17	1663	3256	46	1.96	60.261	1.51	0.04919	0.95	106.0	1.6
15QT46-5@08	2457	5188	69	2.11	61.197	1.58	0.04916	0.80	104.3	1.6
15QT46-5@09	2585	11192	100	4.33	58.923	1.50	0.05031	1.06	108.2	1.6
15QT46-5@14	2903	8213	93	2.83	60.543	1.51	0.04893	0.81	105.5	1.6
15QT46-5@20	3622	12194	123	3.37	58.536	1.50	0.04934	0.65	109.0	1.6
15QT46-5@02	3941	17977	143	4.56	60.124	1.50	0.04936	0.60	106.2	1.6
15QT46-5@05	4502	25336	180	5.63	58.907	1.58	0.04853	0.56	108.5	1.7
15QT46-5@06	4703	18821	160	4.00	59.949	1.59	0.04920	0.64	106.5	1.7
15QT46-5@01	6098	22032	200	3.61	58.440	1.51	0.04866	0.47	109.3	1.6
15QT46-5@16	7225	51164	301	7.08	58.491	1.51	0.04844	0.55	109.2	1.6
15QT46-5@12	5385	29246	221	5.43	56.916	1.53	0.05214	0.98	111.7	1.7
15QT46-5@10	5564	24710	201	4.44	57.259	1.60	0.04812	0.51	111.6	1.8
Yibuchaka										
15QT36-2@1-1	85	176	-	2.08	177.870	2.90	0.05957	6.72	35.6	1.0
15QT36-2@02	94	121	-	1.29	185.413	2.62	0.07464	5.72	33.4	0.9
15QT36-2@04	393	354	3	0.90	188.852	1.78	0.05475	3.94	33.7	0.6
15QT36-2@05	131	237	1	1.80	182.954	2.29	0.06977	6.00	34.1	0.8
15QT36-2@06	148	169	1	1.15	182.348	2.12	0.07073	8.16	34.2	0.8
15QT36-2@07	187	321	2	1.72	181.613	2.42	0.06511	6.88	34.6	0.9
15QT36-2@08	223	676	-	3.04	185.300	2.02	0.06122	4.63	34.1	0.7
15QT36-2@09	99	104	-	1.05	185.086	3.75	0.08761	6.96	32.9	1.3
15QT36-2@10	121	206	-	1.71	178.058	2.33	0.07835	9.45	34.6	0.9
15QT36-2@11	252	500	2	1.98	182.722	2.06	0.05742	6.01	34.7	0.7
15QT36-2@12	166	235	1	1.42	171.846	2.07	0.06174	4.48	36.7	0.8
15QT36-2@13	123	224	1	1.82	177.793	2.34	0.06866	6.94	35.1	0.9
15QT36-2@14	154	406	1	2.63	189.386	2.21	0.07461	6.68	32.7	0.8
15QT36-2@15	1367	1166	10	0.85	182.287	1.54	0.05024	1.76	35.1	0.5
15QT36-2@16	79	84	1	1.06	181.332	3.07	0.08492	10.01	33.7	1.1
15QT36-2@17	162	121	-	0.75	179.409	2.46	0.07227	5.24	34.7	0.9
15QT36-2@18	345	82	2	0.24	183.695	1.93	0.06019	3.35	34.4	0.7
15QT36-2@19	118	144	1	1.22	180.446	2.37	0.08460	6.88	33.9	0.9
15QT36-2@20	247	614	2	2.48	186.130	1.89	0.06140	6.01	33.9	0.7
15QT36-2@21	95	208	-	2.19	173.969	2.48	0.08098	8.94	35.3	0.9

Table S1 continued

Samples	[U] ppm	[Th] ppm	[Pb] ppm	Th/U	^{238}U ^{206}Pb	$\pm\sigma$ %	^{207}Pb ^{206}Pb	$\pm\sigma$ %	207-corr age (Ma)	$\pm\sigma$
Zougouyouchacuo										
15ZB75-1@01	489	224	3	0.46	183.916	1.58	0.04838	3.54	34.9	0.6
15ZB75-1@02	123	87	1	0.71	187.050	2.00	0.06143	4.37	33.7	0.7
15ZB75-1@03	81	31	1	0.38	176.269	2.18	0.06553	8.41	35.6	0.8
15ZB75-1@04	207	147	1	0.71	185.715	1.73	0.05427	3.27	34.3	0.6
15ZB75-1@05	127	88	1	0.69	182.726	1.97	0.06016	4.11	34.6	0.7
15ZB75-1@07	1071	1064	8	0.99	180.380	1.55	0.04887	1.72	35.5	0.6
15ZB75-1@08	1065	926	8	0.87	182.895	1.54	0.04868	1.52	35.1	0.5
15ZB75-1@09	712	765	5	1.07	186.383	1.58	0.04947	1.87	34.4	0.5
15ZB75-1@10	1444	1051	10	0.73	184.839	1.56	0.04879	1.71	34.7	0.5
15ZB75-1@11	145	117	1	0.81	184.443	1.94	0.05700	7.52	34.4	0.7
15ZB75-1@12	140	84	1	0.60	179.849	1.79	0.05763	3.84	35.2	0.6
15ZB75-1@13	166	76	1	0.46	189.077	2.01	0.05725	3.87	33.5	0.7
15ZB75-1@14	410	364	3	0.89	188.010	1.85	0.05053	2.45	34.0	0.6
15ZB75-1@15	420	199	3	0.47	185.359	1.67	0.04794	2.78	34.6	0.6
15ZB75-1@16	143	86	1	0.61	190.423	2.11	0.06284	4.46	33.1	0.7
15ZB75-1@17	307	451	2	1.47	182.303	1.92	0.06971	4.62	34.2	0.7
15ZB75-1@18	215	269	2	1.25	187.283	1.59	0.05927	3.73	33.8	0.5
Jianshan										
15QT43-5@01	1212	1604	10	1.32	179.973	1.61	0.04779	2.42	35.7	0.6
15QT43-5@2	2241	4046	19	1.81	186.992	1.52	0.04866	1.48	34.3	0.5
15QT43-5@3	137	231	1	1.68	181.555	2.26	0.06038	4.10	34.8	0.8
15QT43-5@4	426	767	4	1.80	184.209	1.62	0.05038	3.08	34.7	0.6
15QT43-5@5	452	485	3	1.07	172.298	1.67	0.08143	3.08	35.7	0.6
15QT43-5@6	625	1628	-	2.60	181.238	1.58	0.06582	1.90	34.6	0.6
15QT43-5@7	1339	12	22	0.01	64.973	1.57	0.04893	1.14	98.3	1.5
15QT43-5@8	709	22	20	0.03	37.446	1.52	0.05534	1.01	169	2.5
15QT43-5@9	384	12	13	0.03	32.018	1.51	0.05214	1.06	198	3.0
15QT43-5@10	575	47	28	0.08	22.384	2.13	0.05311	1.66	281	5.9
15QT43-5@11	472	61	24	0.13	21.712	3.74	0.05630	3.24	289	11
15QT43-5@12	399	180	67	0.45	7.173	1.50	0.06725	0.46	841	12
15QT43-5@13	1237	28	21	0.02	61.902	6.83	0.04967	2.38	103	7.0
15QT43-5@14	1404	34	49	0.02	30.619	5.77	0.05297	1.70	206	12
15QT43-5@15	1225	113	209	0.09	6.446	1.52	0.07068	0.37	929	14

TABLE S2. Whole rock major and trace elements compositions and Sr-Nd isotopic ratios of the Baishagang, Yibuchaka, Zougouyouchacuo, and Jianshan volcanic rocks.

Sample	15QT46-2	15QT46-3	15QT46-4	15QT46-5	15QT46-6	15QT46-7
locations	Baishangang	Baishangang	Baishangang	Baishangang	Baishangang	Baishangang
latitude	32°51'33.1"	32°51'33.1"	32°51'33.1"	32°51'33.1"	32°51'33.1"	32°51'33.1"
longitude	86°07'38.3"	86°07'38.3"	86°07'38.3"	86°07'38.3"	86°07'38.3"	86°07'38.3"
SiO ₂	48.3	48.6	48.6	48.6	49.2	50.0
TiO ₂	2.13	2.15	2.13	2.13	2.13	2.13
Al ₂ O ₃	15.8	16.1	15.6	15.5	15.7	15.8
^T Fe ₂ O ₃	11.8	11.7	11.2	11.2	10.4	10.6
MnO	0.18	0.14	0.14	0.20	0.18	0.20
MgO	4.95	3.92	3.59	4.66	4.35	3.82
CaO	7.65	7.96	8.06	6.66	7.69	9.21
Na ₂ O	3.49	4.10	4.69	3.53	4.16	3.69
K ₂ O	2.76	2.47	2.10	3.64	2.64	1.98
P ₂ O ₅	0.57	0.58	0.57	0.56	0.56	0.58
L.O.I	2.24	2.18	2.78	2.77	2.70	1.92
Total	99.91	99.83	99.44	99.42	99.71	99.91
A/CNK	0.70	0.67	0.63	0.71	0.66	0.63
Mg [#]	45	40	39	45	45	42
Sc	21.4	21.3	21.4	21.4	21.7	21.3
Ti	12570	12669	12707	12827	12882	12709
V	179	181	192	178	178	180
Cr	165	166	146	138	147	168
Co	31.1	31.1	32.7	35.1	31.8	33.0
Ni	67.7	71.9	64.7	63.5	68.3	67.6
Cu	28.0	14.7	24.3	15.7	16.8	66.9
Zn	119	114	118	121	114	128
Ga	21.6	21.0	20.3	19.8	21.0	20.3
Ge	3.37	3.39	3.12	3.30	3.25	3.19
Rb	82.8	73.9	68.9	109.2	81.0	57.7
Sr	647	640	617	736	807	565
Y	37.1	36.3	37.4	36.9	37.3	37.6
Zr	334	305	339	338	338	343
Nb	32.3	30.9	32.4	33.1	33.0	32.7
Cs	1.95	1.06	1.36	2.56	10.55	1.23
Ba	706	628	539	795	643	451
La	58.9	57.0	49.0	56.6	57.0	48.3
Ce	118	119	99.7	119	120	98.2
Pr	14.1	13.7	11.9	13.8	13.8	12.0
Nd	55.8	54.1	47.0	54.1	54.5	46.6
Sm	10.8	10.4	9.1	10.5	10.6	8.97
Eu	2.90	2.81	2.40	2.82	2.84	2.42

Gd	10.1	9.67	8.28	9.68	9.79	8.22
Tb	1.53	1.49	1.29	1.48	1.50	1.29
Dy	8.66	8.34	7.29	8.50	8.55	7.30
Ho	1.72	1.67	1.45	1.68	1.69	1.47
Er	4.58	4.39	3.85	4.52	4.53	3.87
Tm	0.650	0.621	0.536	0.636	0.627	0.541
Yb	4.17	3.96	3.49	4.08	4.03	3.47
Lu	0.631	0.606	0.538	0.626	0.624	0.539
Hf	9.03	8.78	7.72	8.91	8.86	7.70
Ta	2.29	2.24	1.95	2.32	2.28	1.94
Pb	13.3	15.4	11.3	13.6	15.1	13.8
Th	8.80	8.69	7.58	8.91	8.79	7.51
U	1.98	1.34	1.16	1.84	1.89	1.29
Sm/La	0.18	0.18	0.19	0.18	0.19	0.19
Th/La	0.15	0.15	0.15	0.16	0.15	0.16
Ba/Rb	8.53	8.50	7.82	7.28	7.93	7.82
Rb/Sr	0.13	0.12	0.11	0.15	0.10	0.10
Eu/Eu*	0.85	0.86	0.84	0.86	0.85	0.86
⁸⁷ Rb/ ⁸⁶ Sr	0.3702			0.4292	0.2907	
⁸⁷ Sr/ ⁸⁶ Sr	0.707270			0.707915	0.707655	
StdErr(abs)	0.000008			0.000008	0.000008	
⁸⁷ / ⁸⁶ Sr (i)	0.70671			0.70727	0.70722	
¹⁴⁷ Sm/ ¹⁴⁴ Nd	0.1169			0.1169	0.1176	
¹⁴³ Nd/ ¹⁴⁴ Nd	0.512570			0.512572	0.512563	
2 s SE	0.000005			0.000005	0.000004	
(¹⁴³ Nd/ ¹⁴⁴ Nd) _i	0.512488			0.512490	0.512480	
ε _{Nd} (t)	-0.2			-0.2	-0.4	

TABLE S2 continued

Sample	15QT43-1	15QT43-2	15QT43-3	15QT43-4	15QT43-5	15QT44-2
locations	Jianshan	Jianshan	Jianshan	Jianshan	Jianshan	Jianshan
latitude	32°56'56.6"	32°56'56.6"	32°56'56.6"	32°56'56.6"	32°57'33"	32°57'33"
longitude	86°30'12.7"	86°30'12.7"	86°30'12.7"	86°30'12.7"	86°29'34.8"	86°29'34.8"
SiO ₂	61.3	61.2	61.2	61.5	61.8	61.9
TiO ₂	1.20	1.20	1.20	1.21	1.16	1.15
Al ₂ O ₃	16.2	16.1	16.2	16.2	16.2	16.1
^T Fe ₂ O ₃	5.11	5.69	5.06	5.85	5.31	5.51
MnO	0.12	0.11	0.12	0.10	0.09	0.09
MgO	2.08	2.07	2.03	2.17	2.25	1.88
CaO	4.09	4.06	4.03	3.97	3.93	3.86
Na ₂ O	3.80	4.17	3.74	4.17	4.08	4.06
K ₂ O	4.08	3.78	4.01	3.83	3.87	3.83
P ₂ O ₅	0.48	0.48	0.48	0.51	0.48	0.46
L.O.I	1.33	0.56	1.34	0.50	0.63	0.72
Total	99.76	99.34	99.46	100.05	99.78	99.56
A/CNK	0.89	0.88	0.91	0.89	0.90	0.90
Mg [#]	45	42	44	42	46	40
Sc	10.4	9.69	9.85	9.82	9.87	9.80
Ti	7423	7057	7165	7136	6996	6896
V	89.9	86.6	86.9	86.4	85.0	84.2
Cr	20.2	26.1	31.5	27.6	31.7	26.6
Co	13.2	13.0	12.2	13.8	13.4	13.3
Ni	13.5	13.0	12.5	13.6	15.7	17.3
Cu	23.6	23.4	22.5	23.8	21.9	25.5
Zn	108	103	110	102	109	113
Ga	23.8	22.8	23.2	22.8	23.2	22.8
Ge	2.46	2.52	2.43	2.48	2.39	2.37
Rb	115	109	111	110	119	119
Sr	784	751	769	740	753	737
Y	18.1	16.4	17.5	16.8	16.8	16.1
Zr	383	365	377	371	362	360
Nb	30.0	28.8	29.3	29.0	28.7	28.5
Cs	2.85	2.36	2.84	2.45	2.64	3.16
Ba	971	992	1067	977	993	982
La	90.1	82.9	87.3	85.9	85.0	69.3
Ce	167	154	163	160	158	128
Pr	19.0	17.7	18.7	18.3	17.8	14.5
Nd	65.9	62.2	65.2	64.3	63.1	51.6
Sm	10.3	9.58	9.91	9.91	9.70	7.98
Eu	2.43	2.41	2.41	2.45	2.37	2.02
Gd	7.92	7.46	7.72	7.77	7.50	6.04
Tb	0.930	0.873	0.915	0.906	0.894	0.720

Dy	4.51	4.27	4.45	4.35	4.28	3.58
Ho	0.797	0.747	0.788	0.772	0.765	0.640
Er	1.98	1.88	1.92	1.91	1.88	1.56
Tm	0.268	0.248	0.259	0.253	0.254	0.210
Yb	1.67	1.57	1.63	1.59	1.57	1.33
Lu	0.246	0.232	0.246	0.242	0.233	0.197
Hf	9.95	9.53	9.83	9.63	9.53	8.19
Ta	1.96	1.92	1.95	1.94	1.98	1.71
Pb	31.0	30.4	29.8	32.8	31.9	25.2
Th	17.0	16.6	16.9	16.6	17.0	14.5
U	3.22	3.12	3.19	3.39	4.00	3.02
Sm/La	0.11	0.12	0.11	0.12	0.11	0.12
Th/La	0.19	0.20	0.19	0.19	0.20	0.21
Ba/Rb	8.47	9.11	9.60	8.91	8.37	8.23
Rb/Sr	0.15	0.14	0.14	0.15	0.16	0.16
Eu/Eu*	0.82	0.87	0.84	0.85	0.85	0.89
⁸⁷ Rb/ ⁸⁶ Sr	0.423	0.419			0.456	0.468
⁸⁷ Sr/ ⁸⁶ Sr	0.707193	0.707242			0.707398	0.707360
StdErr(abs)	0.000009	0.000009			0.000007	0.000010
⁸⁷ / ⁸⁶ Sr (i)	0.706983	0.707033			0.707172	0.707128
¹⁴⁷ Sm/ ¹⁴⁴ Nd	0.0947	0.0931			0.0929	0.0935
¹⁴³ Nd/ ¹⁴⁴ Nd	0.512520	0.512498			0.512485	0.512491
2 s SE	0.000005	0.000006			0.000005	0.000006
(¹⁴³ Nd/ ¹⁴⁴ Nd) _i	0.512499	0.512476			0.512464	0.512470
ε _{Nd} (t)	-1.8	-2.3			-2.5	-2.4

TABLE S2 continued

Sample	15QT44-3	15QT44-4	15QT44-5	15QT44-6	15QT45-1	15QT45-2
locations	Jianshan	Jianshan	Jianshan	Jianshan	Jianshan	Jianshan
latitude	32°57'33"	32°57'33"	32°57'33"	32°57'33"	32°57'46.3"	32°57'46.3"
longitude	86°29'34.8"	86°29'34.8"	86°29'34.8"	86°29'34.8"	86°29'31.5"	86°29'31.5"
SiO ₂	62.2	61.2	61.8	61.4	61.7	62.0
TiO ₂	1.20	1.20	1.18	1.19	1.15	1.17
Al ₂ O ₃	16.1	16.1	16.2	16.1	16.2	16.3
^T Fe ₂ O ₃	5.35	5.20	5.56	5.77	5.53	5.58
MnO	0.09	0.12	0.10	0.10	0.07	0.07
MgO	1.93	2.11	2.19	2.17	1.80	1.74
CaO	3.79	4.10	4.03	4.05	3.92	3.91
Na ₂ O	4.07	3.88	4.10	4.14	4.11	4.11
K ₂ O	3.96	3.83	3.82	3.86	3.79	3.76
P ₂ O ₅	0.49	0.50	0.51	0.52	0.49	0.50
L.O.I	0.85	1.11	0.56	0.42	0.76	0.73
Total	100.09	99.33	99.99	99.71	99.49	99.83
A/CNK	0.90	0.90	0.89	0.88	0.90	0.91
Mg [#]	42	45	44	43	39	38
Sc	9.84	10.1	9.92	9.73	10.1	10.4
Ti	7160	7165	7061	6947	6959	7182
V	88.4	86.8	87.6	85.4	85.9	87.9
Cr	18.9	30.6	19.7	23.5	27.9	33.7
Co	12.6	13.3	13.1	12.7	11.8	12.0
Ni	12.0	14.2	12.2	12.5	16.6	25.1
Cu	22.8	23.1	23.6	23.6	22.6	24.4
Zn	110	113	110	100	95.5	95.1
Ga	23.6	23.1	23.0	22.5	23.2	23.9
Ge	2.59	2.42	2.53	2.54	2.46	2.49
Rb	129	111	117	109	118	123
Sr	766	822	949	982	1063	1245
Y	18.1	17.7	17.4	17.0	16.3	17.0
Zr	384	370	368	361	363	371
Nb	30.1	29.2	28.9	28.4	28.6	29.6
Cs	2.97	2.76	2.49	2.20	3.14	3.09
Ba	1244	902	921	920	1166	1155
La	77.5	89.0	74.8	86.7	84.8	72.5
Ce	144	166	139	161	158	133
Pr	16.5	19.0	16.0	18.5	18.0	15.3
Nd	57.8	66.8	56.1	65.1	63.1	53.7
Sm	8.87	10.28	8.66	10.0	9.62	8.27
Eu	2.12	2.47	2.06	2.38	2.38	2.02
Gd	6.82	8.04	6.76	7.89	7.55	6.43
Tb	0.809	0.962	0.804	0.921	0.885	0.759

Dy	3.93	4.58	3.86	4.43	4.22	3.63
Ho	0.695	0.809	0.678	0.766	0.735	0.636
Er	1.70	2.02	1.68	1.90	1.79	1.54
Tm	0.225	0.260	0.221	0.253	0.232	0.199
Yb	1.39	1.65	1.39	1.58	1.43	1.23
Lu	0.215	0.250	0.207	0.239	0.209	0.173
Hf	8.61	9.75	8.28	9.55	9.43	8.03
Ta	1.75	1.97	1.69	1.90	1.94	1.64
Pb	25.7	30.2	29.5	31.9	28.5	24.7
Th	15.8	17.0	14.7	16.6	17.0	14.3
U	3.35	3.39	3.43	3.10	2.36	1.95
Sm/La	0.11	0.12	0.12	0.12	0.11	0.11
Th/La	0.20	0.19	0.20	0.19	0.20	0.20
Ba/Rb	9.64	8.11	7.87	8.46	9.85	9.37
Rb/Sr	0.17	0.14	0.12	0.11	0.11	0.10
Eu/Eu*	0.83	0.83	0.82	0.82	0.85	0.85
$^{87}\text{Rb}/^{86}\text{Sr}$		0.392				
$^{87}\text{Sr}/^{86}\text{Sr}$		0.707336				
StdErr(abs)		0.000008				
$^{87}/^{86}\text{Sr}$ (i)		0.707141				
$^{147}\text{Sm}/^{144}\text{Nd}$		0.0931				
$^{143}\text{Nd}/^{144}\text{Nd}$		0.512508				
2 s SE		0.000005				
$(^{143}\text{Nd}/^{144}\text{Nd})_i$		0.512486				
$\epsilon_{\text{Nd}}(\text{t})$		-2.08				

TABLE S2 continued

Sample	15QT45-3	15QT45-4	15ZB75-1	15ZB75-2	15ZB75-3	15ZB75-4
locations	Jianshan	Jianshan	Zougouyouchacuo	Zougouyouchacuo	Zougouyouchacuo	Zougouyouchacuo
latitude	32°57'46.3"	32°57'46.3"	33°08'06.9"	33°08'06.9"	33°08'06.9"	33°08'06.9"
longitude	86°29'31.5"	86°29'31.5"	84°56'03.9"	84°56'03.9"	84°56'03.9"	84°56'03.9"
SiO ₂	62.3	61.7	63.1	63.1	63.2	63.2
TiO ₂	1.18	1.16	0.93	0.93	0.92	0.93
Al ₂ O ₃	16.4	16.1	15.6	15.6	15.5	15.6
^T Fe ₂ O ₃	4.92	5.52	4.70	4.72	4.68	4.71
MnO	0.08	0.08	0.05	0.05	0.05	0.04
MgO	1.73	1.93	1.77	1.75	1.89	1.67
CaO	3.91	3.94	4.21	4.17	4.21	4.05
Na ₂ O	4.16	4.08	4.27	4.24	4.27	4.26
K ₂ O	3.90	3.80	3.82	3.87	3.83	3.84
P ₂ O ₅	0.49	0.49	0.40	0.39	0.38	0.36
L.O.I	0.61	0.72	0.76	0.86	0.77	0.85
Total	99.65	99.57	99.55	99.71	99.77	99.60
A/CNK	0.90	0.90	0.83	0.83	0.83	0.84
Mg [#]	41	41	43	42	44	41
Sc	9.80	10.3	7.44	7.67	7.64	7.92
Ti	6951	7058	5265	5356	5435	5620
V	83.1	86.2	66.4	66.0	69.2	66.9
Cr	27.0	29.3	62.2	64.8	68.4	65.7
Co	12.5	12.4	27.3	27.8	24.3	23.3
Ni	15.8	16.9	27.4	28.2	31.5	28.6
Cu	22.8	22.8	32.7	36.9	37.4	38.9
Zn	111	101	82.5	85.2	87.7	89.3
Ga	23.1	23.6	21.0	21.4	21.5	22.3
Ge	2.42	2.47	2.09	2.06	2.10	2.06
Rb	120	121	111	116	114	118
Sr	1212	857	711	720	730	748
Y	16.0	16.7	13.7	14.0	13.9	13.4
Zr	369	370	335	339	342	359
Nb	28.9	29.2	22.2	22.4	22.7	23.9
Cs	2.80	3.80	1.87	2.01	1.79	1.92
Ba	1033	1060	844	873	863	902
La	70.7	72.6	66.6	67.7	68.2	66.5
Ce	132	134	122	124	127	121
Pr	15.1	15.5	13.6	13.7	13.9	13.3
Nd	53.6	54.0	48.3	49.1	49.6	47.0
Sm	8.19	8.23	6.92	7.00	7.12	6.77
Eu	2.04	2.02	1.68	1.70	1.78	1.76
Gd	6.18	6.34	5.07	5.23	5.20	5.01
Tb	0.739	0.748	0.566	0.581	0.582	0.571

Dy	3.56	3.63	2.75	2.80	2.86	2.66
Ho	0.625	0.629	0.483	0.501	0.491	0.471
Er	1.53	1.53	1.17	1.21	1.23	1.19
Tm	0.196	0.200	0.156	0.162	0.160	0.152
Yb	1.24	1.25	0.948	0.986	0.970	0.923
Lu	0.184	0.183	0.145	0.152	0.148	0.145
Hf	8.33	8.17	7.40	7.58	7.86	7.99
Ta	1.71	1.67	1.14	1.17	1.20	1.20
Pb	31.3	26.0	20.4	20.8	21.1	21.9
Th	15.0	14.9	16.3	16.9	16.9	17.2
U	2.75	2.46	2.64	2.66	2.72	2.72
Sm/La	0.12	0.11	0.10	0.10	0.10	0.10
Th/La	0.21	0.21	0.25	0.25	0.25	0.26
Ba/Rb	8.64	8.74	7.58	7.54	7.54	7.62
Rb/Sr	0.10	0.14	0.16	0.16	0.16	0.16
Eu/Eu*	0.88	0.86	0.87	0.86	0.89	0.93
$^{87}\text{Rb}/^{86}\text{Sr}$					0.453	0.458
$^{87}\text{Sr}/^{86}\text{Sr}$					0.706103	0.706102
StdErr(abs)					0.000010	0.000014
$^{87}/^{86}\text{Sr}$ (i)					0.705878	0.705874
$^{147}\text{Sm}/^{144}\text{Nd}$					0.0867	0.0869
$^{143}\text{Nd}/^{144}\text{Nd}$					0.512541	0.512533
2 s SE					0.000005	0.000006
$(^{143}\text{Nd}/^{144}\text{Nd})_i$					0.512521	0.512513
$\epsilon_{\text{Nd}}(\text{t})$					-1.4	-1.6

TABLE S2 continued

Sample	15ZB75-5	15ZB76-1	15ZB76-2	15ZB76-4	15QT34-1
locations	Zougouyouchacuo	Zougouyouchacuo	Zougouyouchacuo	Zougouyouchacuo	Yibuchaka
latitude	33°08'06.9"	33°08'00.5"	33°08'00.5"	33°08'00.5"	32°58.177'
longitude	84°56'03.9"	84°56'38.8"	84°56'38.8"	84°56'38.8"	86°37.267'
SiO ₂	63.3	62.8	62.9	62.8	59.2
TiO ₂	0.93	0.93	0.94	0.93	1.39
Al ₂ O ₃	15.6	15.5	15.5	15.5	16.1
^T Fe ₂ O ₃	4.71	4.72	4.70	4.70	5.33
MnO	0.05	0.07	0.06	0.05	0.14
MgO	1.87	2.25	2.35	2.22	1.70
CaO	4.24	4.50	4.47	4.50	5.14
Na ₂ O	4.23	4.25	4.24	4.24	3.95
K ₂ O	3.84	3.82	3.81	3.84	3.67
P ₂ O ₅	0.40	0.41	0.39	0.40	0.56
L.O.I	0.86	0.51	0.46	0.54	2.53
Total	99.973	99.737	99.8	99.667	99.73
A/CNK	0.83	0.80	0.81	0.80	0.81
Mg [#]	44	49	50	48	39
Sc	7.90	7.57	7.75	7.79	12.1
Ti	5485	5479	5527	5538	8728
V	68.2	82.4	82.6	83.8	100.5
Cr	63.8	61.4	60.8	61.3	69.6
Co	25.2	29.5	37.8	29.5	17.3
Ni	28.5	30.5	29.9	30.7	35.8
Cu	36.6	34.6	39.2	26.2	41.2
Zn	86.4	89.3	86.8	86.5	107
Ga	21.8	21.4	21.6	21.5	23.5
Ge	2.12	2.22	2.12	2.14	2.44
Rb	116	115	118	117	109
Sr	737	735	736	739	924
Y	13.8	14.2	14.3	14.4	18.4
Zr	349	343	347	346	404
Nb	23.0	23.1	23.4	23.6	31.9
Cs	1.78	2.54	2.31	2.39	68.5
Ba	865	877	856	876	1016
La	69.0	68.9	65.9	68.6	79.1
Ce	127	129	125	126	145
Pr	14.0	14.2	13.7	14.2	16.4
Nd	49.7	50.0	48.8	49.8	56.5
Sm	6.94	7.17	6.93	7.02	8.45
Eu	1.78	1.72	1.73	1.74	2.14
Gd	5.33	5.28	5.21	5.34	6.55
Tb	0.580	0.606	0.583	0.601	0.772

Dy	2.80	2.87	2.84	2.89	3.72
Ho	0.492	0.492	0.501	0.496	0.676
Er	1.20	1.24	1.25	1.24	1.69
Tm	0.165	0.164	0.168	0.165	0.226
Yb	0.952	0.993	1.02	1.00	1.42
Lu	0.149	0.155	0.158	0.156	0.214
Hf	8.00	7.65	7.81	7.89	8.27
Ta	1.20	1.19	1.20	1.23	1.70
Pb	21.7	23.1	21.3	21.7	23.8
Th	17.3	17.5	17.1	17.0	14.6
U	2.75	2.80	2.80	2.80	2.45
Sm/La	0.10	0.10	0.11	0.10	0.11
Th/La	0.25	0.25	0.26	0.25	0.18
Ba/Rb	7.49	7.62	7.27	7.51	9.34
Rb/Sr	0.16	0.16	0.16	0.16	0.12
Eu/Eu*	0.90	0.86	0.88	0.87	0.88
⁸⁷ Rb/ ⁸⁶ Sr	0.454	0.453	0.463		0.341
⁸⁷ Sr/ ⁸⁶ Sr	0.706118	0.706094	0.706077		0.706621
StdErr(abs)	0.000007	0.000009	0.000010		0.000007
⁸⁷ / ⁸⁶ Sr (i)	0.705893	0.705869	0.705846		0.706451
¹⁴⁷ Sm/ ¹⁴⁴ Nd	0.0843	0.0867	0.0858		0.0904
¹⁴³ Nd/ ¹⁴⁴ Nd	0.512538	0.512540	0.512550		0.512524
2 s SE	0.000005	0.000005	0.000006		0.000005
(¹⁴³ Nd/ ¹⁴⁴ Nd) _i	0.512519	0.512520	0.512530		0.512503
ε _{Nd} (t)	-1.4	-1.4	-1.2		-1.8

Table S2 continued

Sample	15QT34-2	15QT34-3	15QT36-2	15QT36-3	15QT36-4
locations	Yibuchaka	Yibuchaka	Yibuchaka	Yibuchaka	Yibuchaka
latitude	32°58.177'	32°58.177'	32°58.177'	32°58.177'	32°58.177'
longitude	86°37.267'	86°37.267'	86°37.267'	86°37.267'	86°37.267'
SiO ₂	60.7	58.8	58.5	58.4	59.2
TiO ₂	1.49	1.38	1.39	1.38	1.38
Al ₂ O ₃	17.0	15.9	15.9	15.9	16.1
^T Fe ₂ O ₃	4.82	6.15	6.12	6.40	6.16
MnO	0.04	0.16	0.15	0.15	0.16
MgO	1.07	2.36	2.09	2.43	1.68
CaO	4.22	5.04	4.99	4.73	4.87
Na ₂ O	4.37	3.77	3.92	3.81	3.95
K ₂ O	3.96	3.85	3.88	3.88	3.82
P ₂ O ₅	0.57	0.57	0.57	0.57	0.57
L.O.I	1.83	2.11	2.03	1.86	1.69
Total	100.09	100.06	99.57	99.48	99.63
A/CNK	0.89	0.81	0.81	0.83	0.83
Mg [#]	31	43	40	43	35
Sc	10.5	12.2	11.9	11.9	11.9
Ti	9074	8710	8509	8385	8540
V	97.2	100.7	98.1	97.4	99.7
Cr	84.4	91.5	75.8	77.0	85.4
Co	14.8	23.0	18.3	19.4	14.6
Ni	28.5	46.2	39.0	41.2	30.9
Cu	41.1	41.2	39.3	40.1	40.9
Zn	87	130	128	117	127
Ga	24.6	23.9	23.5	23.2	23.6
Ge	2.47	2.84	2.59	2.68	2.79
Rb	106	122	133	126	132
Sr	968	955	916	909	913
Y	16.5	18.9	19.7	18.8	19.8
Zr	411	411	397	396	401
Nb	33.2	32.5	31.8	31.7	32.1
Cs	36.1	51.2	118.8	90.2	145
Ba	1042	1073	968	962	956
La	82.6	84.0	80.5	81.5	80.9
Ce	148	153	149	150	149
Pr	16.6	17.3	16.8	17.1	16.8
Nd	56.9	60.2	59.1	59.2	58.2
Sm	8.38	8.92	8.74	8.77	8.66
Eu	2.19	2.17	2.16	2.17	2.15
Gd	6.33	6.92	6.81	6.80	6.81
Tb	0.723	0.800	0.787	0.803	0.791

Dy	3.45	3.92	3.89	3.87	3.88
Ho	0.604	0.682	0.690	0.698	0.695
Er	1.49	1.69	1.73	1.72	1.75
Tm	0.195	0.226	0.232	0.229	0.235
Yb	1.19	1.42	1.44	1.43	1.50
Lu	0.175	0.209	0.226	0.217	0.233
Hf	8.46	8.30	8.05	8.13	8.18
Ta	1.75	1.71	1.69	1.69	1.68
Pb	29.3	24.4	23.2	24.1	23.8
Th	15.2	15.6	14.9	15.5	14.9
U	2.38	2.57	2.50	2.58	2.47
Sm/La	0.10	0.11	0.11	0.11	0.11
Th/La	0.18	0.19	0.19	0.19	0.18
Ba/Rb	9.79	8.79	7.28	7.63	7.24
Rb/Sr	0.11	0.13	0.15	0.14	0.14
Eu/Eu*	0.92	0.84	0.85	0.86	0.85
⁸⁷ Rb/ ⁸⁶ Sr	0.318	0.370	0.420	0.401	0.418
⁸⁷ Sr/ ⁸⁶ Sr	0.706616	0.706667	0.706582	0.706621	0.706609
StdErr(abs)	0.000009	0.000008	0.000006	0.000009	0.000007
⁸⁷ / ⁸⁶ Sr (i)	0.706458	0.706484	0.706373	0.706422	0.706401
¹⁴⁷ Sm/ ¹⁴⁴ Nd	0.0891	0.0895	0.0894	0.0895	0.0899
¹⁴³ Nd/ ¹⁴⁴ Nd	0.512513	0.512522	0.512512	0.512523	0.512525
2 s SE	0.000004	0.000006	0.000005	0.000006	0.000005
(¹⁴³ Nd/ ¹⁴⁴ Nd) _i	0.512493	0.512502	0.512492	0.512503	0.512505
ε _{Nd} (t)	-1.9	-1.8	-2.0	-1.8	-1.7

$Mg^{\#} = Mg^{2+} \times 100 / (Mg^{2+} + Fe^{2+})$; $A/CNK = Al_2O_3 / (CaO + Na_2O + K_2O)$ molar; $Eu/Eu^* = Eu_N / (Sm_N \times Gd_N)^{(1/2)}$;
 $^{87}Rb/^{86}Sr$ and $^{147}Sm/^{144}Nd$ are calculated using whole-rock Rb, Sr, Sm and Nd contents; $(^{87}Sr/^{86}Sr)_i = (^{87}Sr/^{86}Sr)_s$
 $- (^{87}Rb/^{86}Sr)_s \times (e^{\lambda t} - 1)$, $(^{143}Nd/^{144}Nd)_i = (^{143}Nd/^{144}Nd)_{sample} - (^{147}Sm/^{144}Nd)_{sample} \times (e^{\lambda t} - 1)$,
 $\epsilon_{Nd}(t) = [(^{143}Nd/^{144}Nd)_s / (^{143}Nd/^{144}Nd)_{CHUR} - 1] \times 10000$.

TABLE S3 The assimilation and fractional crystallization (AFC) for Late Eocene post-collisional magmatic rocks in the southern Qiangtang terrane

Initial melts composition:

Sample	SiO ₂	TiO ₂	Al ₂ O ₃	TFe ₂ O ₃	MnO	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅	H ₂ O	P	f _{O2}	Sr (ppm)	⁸⁷ / ₈₆ Sr (i)
NDC11	47.4	2.37	15.9	10.6	0.16	7.31	8.22	3.79	1.15	0.84	2	2 kbar	FMQ +1.5	1458	0.70446

The starting material is from sample NDC11 in Guo and Wilson (2019). The initial temperature of mineral crystallization is 1160°C according to the calculate by pMELTS. We assumed f_{O2}=FMQ + 1.5 in order to maintain the high TiO₂ content in the residual melts. To produce the 4-wt.%-MgO melts, olivine (6%), spinel (8%), clinopyroxene (6%) and plagioclase (12%) are fractional crystallization.

Assimilation and fractional crystallization (AFC) for 4-wt.%-MgO melts:

	Olivine	Spinel	Clinopyroxene	Plagioclase
Distribution coefficient for Sr in mineral	0.014	0	0.13	1.8
Proportion of mineral	0.06	0.08	0.06	0.12
Bulk distribution coefficient for Sr	0.2246			
Magma initial Sr content (ppm)	1460			
4 wt.%-MgO melts Sr contents (ppm)	1969			
Assimilant Sr contents (ppm)	500			
Assimilant Sr isotope	0.7200			
Assimilant bulk distribution coefficient for Sr	1.5			

The Sr contents of the 4-wt.%-MgO melts were calculated based on strontium's partition coefficients in olivine, spinel, clinopyroxene, and plagioclase and their estimated mineral proportions. The strontium's partition coefficients are from Laubier et al., (2014). The Sr isotope ratio of the 4-wt.%-MgO melt is equal to that of the initial melt, since fractional crystallization does not change the radiogenic composition of melts. The AFC model was developed based on Nishimura (2013)

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TABLE S4. Estimated pressure and temperature of partial melting condition

Samples	NDC11
Add Ol (%)	18
SiO ₂	46.1
TiO ₂	1.99
Al ₂ O ₃	13.2
FeO	9.18
MnO	0.16
MgO	13.8
CaO	6.88
Na ₂ O	3.16
K ₂ O	0.96
P ₂ O ₅	2.3
H ₂ O	3.0
^T Fe ₂ O ₃	0.88
Total	99.3
T(°C)	1400
P(GPa)	2.2

We use an $\text{Fe}^{2+}/\Sigma\text{Fe}$ ratio of 0.9 to estimate the primary melt composition. We assumed that the primary melts contained 3.0 wt.% H₂O, because amphibole was observed in the sample. An equilibrium mantle olivine composition with a Fo = 90 was used in the calculations because the source of late Eocene post-collisional rocks was enriched mantle. Estimated pressure and temperature of partial melting condition are calculated according to the method from Lee et al. (2009).

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FIGURE S1 Th versus Rb, Sr, Ba, La, Hf and Cs for the Baishagang basalts