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Data Repository

Supplementary files.

Supplementary file 1. Laboratory methods.

Supplementary file 2a. Original major oxides (wt%) and trace elements (ppm) concentrations of the east Purang dolerites.

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Supplementary file 3. Whole-rock Sr-Nd isotopic data of the the west and east Purang dolerites.

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Supplementary file 5a. Zircon LA-ICP-MS U-Pb isotopic data of the west (sample JYM-24) and east (sample LAC-31 and CMN-30) Purang dolerites.

Supplementary file 5b. Zircon LA-ICP-MS U-Pb isotopic data of the Standard zircons (Temora and Qinghu).

Supplementary file 6a. Lu-Hf isotopic compositions for zircons of the west and east Purang dolerites.

Supplementary file 6b. Lu-Hf isotopic compositions for Standard zircons (GJ-1, 91500 and Penglai).

Supplementary file 7. References below represent the sources for U-Pb age and Hf-isotope data of zircons from Gangdese Arc plutons and YZSZ ophiolites in Fig. 9.

Link location: http://www.geosociety.org/datarepository/2018/2018xxx_Tables.xls

Zheng et al. Supplementary files.

Supplementary file 1. Laboratory methods.

Petrographic methods

Four polished thin sections were prepared for each mafic dike sample and were investigated under both transmitted and reflected light using an OLYMPUS BX51 optical microscope at the School of Marine Science, Sun Yat-sen University (SYSU), Guangzhou, China.

Bulk-rock analysis

All mafic dike samples were analyzed for their whole-rock major and minor element contents. Samples were first crushed into small blocks and were ultrasonically cleaned in purified water with 3% HNO_3, and then washed with distilled water alone. Subsequently, they were dehydrated and handpicked to eliminate any visible contamination. The blocks were crushed and ground to less than 200 meshes in an agate ring mill, and the final powders were used for geochemical analyses. Major-element oxides were determined by the X-ray fluorescence (XRF) method in fused glass disks using a Rigaku 100e spectrometer at the Guangzhou ALS Chemex Company, China. Analyses of the United States Geological Survey (USGS) rock standard (BCR-2) indicate precision and accuracy better than 2% for SiO_2, TiO_2, Al_2O_3, $Fe_2O_3^t$ and CaO, and better than 4% for the rest major-element oxides. Analytical uncertainties for major elements range between 1 and 3%. Loss on ignition (LOI) was determined by gravimetric techniques in which the sample is heated in a closed container and the water vapor is collected in a separate tube, condensed, and then weighed. A detailed description of the analytical method can be found in Chen et al. (2014). Trace element abundances were measured at the Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (GIGCAS). GIGCAS using a PE Elan 6000 inductively coupled plasma-mass spectrometer (ICP-MS). The USGS reference material BCR-2 was used to monitor the analytical accuracy. Analytical uncertainties are ±5-10% for trace elements and ±5% for the lanthanide series of elements. A detailed description of the analytical method can be found in Qi and Grégoire (2000). Whole-rock major and trace element data are given in the Supplementary file 2a,b.

Sr-Nd isotope analysis

Bulk-rock Sr-Nd isotopic compositions of the investigated mafic dikes were measured using a Neptune Plus (Thermo Fisher Scientific, MA, USA) mutli-collector–inductively coupled plasma–mass spectrometer (MC-ICP-MS) with 9 Faraday cup collectors and 8 ion counters at the GIGCAS. A detailed description of the analytical method can be found in Lee et al. (2012). Measured $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios were normalized to $^{86}Sr/^{88}Sr = 0.1194$ and $^{146}Nd/^{144}Nd = 0.7219$ (Thirlwall, 1991) for mass fractionation. Whole-rock Sr-Nd isotopic data are presented in the Supplementary file 3.

Investigation methods of zircons

Separation and imaging

Zircon separation from crushed mafic dike specimens was done at the GIGCAS following density and isodynamic magnetic separation techniques. Individual zircons were handpicked under a binocular microscope, mounted in epoxy resin disks and polished until the centres of the grains were exposed. The zircon grains were imaged under reflected and transmitted light using the optical microscope employed for the petrographic description of our samples. The micro-structural characteristics and internal textures of zircons were studied in back-scattered electron (BSE) and cathodoluminescence (CL) images using a CARL ZEISS SIGMA scanning electron microscope (SEM) at GIGCAS.

U-Pb dating and REE-geochemistry

The same SEM was employed to choose the target sites for the compositional and isotopic analyses of zircons. Concentrations of rare earth elements (REE: lanthanides + Y) and U-Pb analyses were measured by LA-ICP-MS using an Agilent 7500a ICP-MS coupled with a Resonetics RESOlution M-50 ArF Excimer laser source (λ = 193 nm) at the State Key Laboratory of Isotope Geochemistry, GIGCAS. All analyses were done with a spot size of 33 μm, laser energy of 80 mJ, frequency of 10 Hz and ablation time of 40 s. Helium was used as the carrier gas through the ablation cell with Ar makeup gas being connected via a T-piece and sourced from a Cetac Aridus II desolvating nebulizer. External calibration was achieved using a NIST SRM610 silicate glass and a TEMORA zircon ($^{206}Pb/^{238}U$ age = 416.8 Ma; Black et al., 2004) and QINGHU zircon ($^{206}Pb/^{238}U$ age = 159.5 Ma; Li et al., 2009). Quantitative analyses for trace elements were obtained through calibration of relative element sensitivities using the NIST SRM-610 standard glass and normalization of each analysis to ^{29}Si that was used as internal standard. The standard zircons TEMORA and QINGHU were adopted as external standards to calculate age. A detailed description of the analytical method can be found in Li et al. (2012). Raw data were using the data reduction software ICPMSDataCal (Liu et al., 2010) and then processed using the ISOPLOT 3.0 software (Ludwig, 2003) to calculate isotopic ratios and ages. All ages were calculated with 2σ errors. U-Pb isotopic data of zircons are presented in the Supplementary file 4a,b and REE analyses of zircons are presented in the Supplementary file 5.

Lu-Hf isotope analysis

Near concordant U-Pb zircon ablation sites from each of the samples were re-analyzed to measure their respective Lu-Hf isotopic compositions. *In-situ* zircon Lu-Hf isotopic measurements were carried out on the dated spots of the investigated zircons using a Neptune Plus MC-ICP-MS, coupled to an ArF excimer laser ablation system at the State Key Laboratory of Isotope Geochemistry, GIGCAS. Helium was used as the carrier gas through the ablation cell with Ar makeup gas being connected via a T-piece and sourced from a Cetac Aridus II desolvating nebulizer. After initial set-up and tuning, a 2% HNO_3 solution was aspirated during the ablation analyses. Conditions for Lu-Hf isotopic analyses were 80 mJ/pulse laser energy density and repetition rate of 8 Hz with a spot diameter of 45 μm. Detailed descriptions of instrument conditions, analytical methods, and off-line analyses are given in Wu et al. (2006, 2007). Depleted mantle model ages (T_{DM}) and crustal model ages (T_{DM}^{C}) were calculated in reference to the depleted mantle (DM) at a present day $^{176}Hf/^{177}Hf$ ratio of 0.28325 and $^{176}Lu/^{177}Hf$ ratio of 0.0384 (Griffin et al., 2000) and an average continental crust $^{176}Hf/^{177}Hf$ ratio of 0.015 (Griffin et al., 2002), respectively. In order to evaluate the quality of the acquired data the GJ-1, 91500 and Penglai zircon was employed as an external standard and its $^{176}Hf/^{177}Hf$ ratio was found to be 0.282012 ± 25 (2σ), 0.282307 ± 31 (2σ) and 0.282906 ± 10 (2σ) in accordance with the recommended value (Wu et al., 2006; Yuan et al., 2008; Li et al.,2010). Some analyses were rejected due to extremely variable signal and high ^{178}Hf /^{177}Hf and $^{176}Hf/^{177}Hf$ uncertainties (> 20 %) that is likely due to ablation through different compositional and/or age zones within an individual zircon grain. The uncertainty propagation of the epsilon notation also includes the uncertainty of the $^{207}Pb/^{206}Pb$ crystallization age, as it is time integrated. Although this may be an over propagation of uncertainty, we prefer this conservative approach for the epsilon notation when defining specific fields of similar ε_{Hf} compositions. Uncertainties that incorporate the crystallization age uncertainty are on average 50% (1σ = 20%) larger than uncertainties that do not consider the crystallization age uncertainty. Lu-Hf isotopic data are presented in the Supplementary file 6a and the data of standard zircons GJ-1, 91500 and Penglai are presented in the Supplementary file 6b.

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Supplementary file 2a. Original major oxides (wt%) and trace elements (ppm) concentrations of the east Purang dolerites.

Sample	LACS-1	LACS-7	LACS-9	LACS-23	LACS-27	LACS-28	LACS-31	CMN-23	CMN-27	CMN-29	CMN-30
	East Purang dolerites										
Major oxides (wt. %)											
SiO_2	49.78	49.35	49.70	44.41	44.48	47.94	49.40	47.97	37.89	44.68	47.91
TiO_2	1.33	1.32	1.22	1.80	1.81	1.62	0.98	0.81	1.27	1.21	0.97
Al_2O_3	14.89	15.08	15.35	14.48	14.89	14.82	15.55	14.25	13.37	13.24	14.35
Fe_2O_3t	11.31	10.60	10.25	13.08	13.15	12.92	9.53	8.93	10.57	10.57	9.26
MnO	0.19	0.16	0.16	0.19	0.19	0.21	0.15	0.16	0.18	0.18	0.17
MgO	6.81	7.11	6.73	7.46	7.62	6.55	7.95	6.41	5.96	6.02	6.17
CaO	10.82	11.07	10.85	12.65	12.24	10.42	11.40	15.67	24.11	19.33	14.82
Na_2O	2.95	2.97	3.21	1.93	1.95	3.09	2.89	2.47	1.75	1.66	2.86
K_2O	0.12	0.10	0.12	0.16	0.14	0.11	0.07	0.18	0.02	0.12	0.09
P_2O_5	0.08	0.07	0.10	0.11	0.12	0.11	0.08	0.08	0.08	0.08	0.10
LOI	1.43	1.49	1.58	3.52	3.31	2.50	1.39	2.56	4.89	2.90	3.03
Total	99.75	99.36	99.31	99.87	99.98	100.33	99.44	99.60	100.15	100.05	99.81
$Mg^{\#}$	58	61	60	57	57	54	66	63	57	57	61
Trace elements (ppm)											
Sc	45.9	45.9	36.0	48.5	54.4	45.1	34.4	79.8	60.9	80.1	38.0
Ti	7971	7911	7313	10788	10848	9709	5874	4855	7612	7253	5814
V	324	313	281	381	387	384	245	257	379	371	232
Cr	184	175	167	131	149	147	251	236	170	189	149
Co	45.4	45.4	39.5	52.2	52.4	46.4	39.5	42.4	49.9	48.7	35.6
Ni	67.9	72.9	62.4	65.2	59.6	81.3	84.2	69.2	62.5	59.9	74.1
Cu	72.2	64.6	66.4	14.2	12.8	12.3	74.1	71.2	82.5	75.2	41.7

Zn	135	97.4	125	159	134	181	117	161	198	175	108
Ga	17.2	16.2	16.2	13.7	13.6	17.5	14.1	16.0	11.3	17.4	15.8
Rb	2.95	3.68	1.88	1.62	1.64	1.20	0.81	4.95	0.41	2.34	2.19
Sr	130	124	118	378	415	124	130	519	78.9	279	469
Y	31.2	27.1	27.1	37.6	40.9	35.6	21.1	29.7	28.5	31.7	29.6
Zr	90.3	75.7	72.6	111	110	64.0	54.0	75.1	78.1	71.8	82.5
Nb	2.13	1.34	1.13	2.13	1.81	1.73	0.70	2.45	2.03	1.44	1.67
Cs	0.24	0.08	0.03	0.09	0.13	0.04	0.05	0.71	0.64	0.53	0.31
Ba	23.3	9.79	7.37	15.4	17.3	11.9	6.09	170	19.4	73.3	82.1
La	2.85	2.09	2.42	3.26	3.50	2.86	1.81	2.87	2.35	2.57	2.99
Ce	9.41	7.51	7.79	11.50	11.90	10.40	5.70	8.94	7.93	8.16	10.40
Pr	1.45	1.16	1.32	1.72	1.92	1.58	1.01	1.32	1.20	1.33	1.59
Nd	7.93	6.53	7.35	9.36	10.40	8.69	5.50	7.04	6.85	7.02	7.98
Sm	2.69	2.32	2.56	3.15	3.69	3.20	2.02	2.47	2.22	2.53	2.76
Eu	0.98	0.85	1.01	1.01	1.15	1.04	0.79	0.95	0.93	0.97	0.98
Gd	3.45	3.06	3.71	4.42	4.69	4.20	2.78	3.28	3.37	3.46	3.14
Tb	0.66	0.57	0.66	0.80	0.89	0.77	0.50	0.61	0.59	0.63	0.67
Dy	4.82	3.92	4.52	5.68	6.27	5.45	3.44	4.10	3.76	4.16	4.48
Ho	0.99	0.84	0.95	1.19	1.28	1.13	0.73	0.90	0.82	0.88	1.09
Er	3.04	2.48	2.90	3.48	3.71	3.21	2.20	2.51	2.31	2.73	3.10
Tm	0.41	0.33	0.41	0.52	0.55	0.50	0.33	0.39	0.35	0.38	0.48
Yb	2.60	2.28	2.69	3.37	3.60	3.15	2.11	2.41	2.32	2.54	2.73
Lu	0.39	0.34	0.39	0.48	0.52	0.45	0.31	0.34	0.34	0.37	0.41
Hf	2.34	1.83	1.97	2.57	2.52	2.03	1.47	1.77	1.77	1.46	2.01
Ta	0.74	0.29	0.19	0.38	0.17	0.44	0.11	0.40	0.11	0.28	0.16
Th	0.26	0.16	0.08	0.15	0.16	0.12	0.06	0.26	0.14	0.13	0.11

U	0.26	0.20	0.07	0.22	0.27	0.27	0.07	0.29	0.46	0.22	0.31
ΣREE	41.7	34.3	38.7	49.9	54.1	46.6	29.2	38.1	35.3	37.7	42.8
δ_{Eu}	0.98	0.97	1.00	0.83	0.85	0.87	1.02	1.02	1.04	1.00	1.01
$(La/Yb)_N$	0.79	0.66	0.65	0.69	0.70	0.65	0.62	0.85	0.73	0.73	0.79

Supplementary file 2b. Original major oxides (wt%) and trace elements (ppm) concentrations of the west Purang dolerites.

Sample	JYM-4	JYM-5	JYM-11	JYM-15	JYM-24	JYM-39	JYM-40	JYM-42	JYM-43	JYM-49	JYM-50
	West Purang dolerites										
Major oxides (wt. %)											
SiO_2	48.37	49.05	49.71	48.14	47.64	49.58	49.75	48.97	50.21	48.59	48.15
TiO_2	2.43	2.38	2.37	2.19	2.59	2.41	2.41	2.48	2.44	2.46	2.44
Al_2O_3	14.68	15.17	16.64	16.07	14.94	14.51	14.83	15.06	14.84	15.07	15.10
Fe_2O_3t	12.95	12.72	10.68	11.31	12.84	12.26	12.65	12.63	12.51	12.68	12.99
MnO	0.23	0.22	0.20	0.20	0.23	0.50	0.35	0.28	0.38	0.27	0.23
MgO	4.67	4.49	3.15	4.11	3.85	4.46	4.17	4.24	4.37	4.09	4.60
CaO	7.11	6.59	7.73	8.57	8.20	6.61	6.45	6.63	5.17	7.27	6.67
Na_2O	3.73	3.69	3.92	3.38	3.74	5.08	5.31	5.26	5.58	4.87	3.92
K_2O	2.10	2.51	2.36	2.13	1.81	0.83	0.51	0.25	0.60	0.56	1.86
P_2O_5	0.31	0.28	0.28	0.29	0.51	0.48	0.48	0.48	0.49	0.46	0.35
LOI	2.96	3.03	2.55	3.04	3.06	2.54	2.83	3.29	3.03	3.00	3.32
Total	99.71	100.35	99.76	99.56	99.57	99.43	99.85	99.61	99.75	99.42	99.83
$Mg^{\#}$	46	45	41	46	41	46	43	44	45	43	45
Trace elements (ppm)											
Sc	29.6	28.3	28.5	28.6	25.5	30.9	29.2	30.6	30.8	30.5	32.3
Ti	14564	14265	14205	13126	15523	14444	14444	14864	14624	14744	14624

V	309	302	313	330	292	303	292	300	301	307	317
Cr	62.5	47.8	20.8	33.7	22.5	47.2	47.8	47.6	42.9	62.7	42.3
Co	34.3	32.7	25.5	30.8	30.1	31.0	30.6	32.1	32.1	31.8	35.0
Ni	33.9	20.5	10.0	9.1	11.8	15.9	12.6	16.3	13.1	24.1	11.3
Cu	16.5	14.9	16.7	14.8	24.0	21.3	19.4	17.1	18.0	28.8	21.5
Zn	167	198	214	164	174	185	175	192	169	175	193
Ga	21.1	19.7	21.4	21.0	23.1	22.0	23.3	24.8	22.4	25.6	22.6
Rb	64.4	80.3	68.1	61.4	47.7	35.6	20.9	14.0	27.4	20.0	49.2
Sr	558	815	696	549	642	581	486	254	682	339	679
Y	30.1	27.6	29.6	27.7	33.4	37.5	36.9	36.6	36.6	36.9	33.2
Zr	207	217	206	194	217	234	242	241	242	252	216
Nb	83.8	82.7	79.3	75.9	88.8	97.4	97.6	98.7	96.8	101.0	82.9
Cs	1.01	1.23	0.45	0.95	0.41	1.15	0.75	0.72	0.92	0.60	0.47
Ba	834	1044	826	688	713	928	434	158	492	507	987
La	48.4	47.5	50.7	49.0	59.5	64.4	62.9	61.9	64.0	62.4	53.6
Ce	91.7	87.7	94.4	90.2	109	118	115	113	116	113	98.8
Pr	9.10	8.38	9.27	8.90	12.0	12.0	11.8	11.4	11.7	11.5	10.0
Nd	33.6	30.4	34.1	31.9	42.2	44.0	42.4	41.3	42.9	42.1	37.0
Sm	5.88	5.48	5.83	5.63	7.78	7.41	7.46	7.23	7.30	7.40	6.58
Eu	2.08	1.99	2.25	2.01	2.34	2.19	2.15	2.27	2.21	2.23	2.09
Gd	5.92	5.71	5.98	5.62	6.81	7.34	7.23	6.98	7.07	6.96	6.41
Tb	0.87	0.79	0.88	0.80	1.04	1.02	1.03	0.99	1.02	0.98	0.93
Dy	4.96	4.47	5.00	4.65	5.79	5.85	5.97	5.62	5.80	5.68	5.24
Ho	1.00	0.87	0.97	0.89	1.25	1.14	1.12	1.13	1.13	1.15	1.07
Er	2.72	2.58	2.93	2.65	3.41	3.18	3.37	3.28	3.26	3.20	3.07
Tm	0.39	0.39	0.41	0.36	0.48	0.47	0.45	0.46	0.45	0.45	0.43

Yb	2.62	2.37	2.58	2.33	2.88	3.01	2.91	2.82	2.84	3.03	2.82
Lu	0.37	0.38	0.36	0.35	0.45	0.45	0.43	0.43	0.42	0.44	0.40
Hf	4.37	4.67	4.56	3.97	4.54	4.63	4.61	4.85	4.55	5.12	4.63
Ta	4.23	4.52	4.46	4.22	4.16	4.87	5.06	4.50	5.22	5.07	4.48
Th	8.34	8.26	7.90	7.86	10.50	11.00	11.10	10.80	11.10	11.00	8.96
U	1.97	2.17	1.95	1.72	1.90	2.39	2.33	2.16	2.25	2.37	1.81
ΣREE	210	199	216	205	255	270	264	259	266	261	228
δ_{Eu}	1.08	1.09	1.16	1.09	0.98	0.91	0.89	0.98	0.94	0.95	0.99
$(La/Yb)_N$	13	14	14	15	15	15	16	16	16	15	14

Supplementary file 3. Whole-rock Sr-Nd isotopic data of the west and east Purang dolerites.

Sample	Rock type	Age(Ga)	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	2σ	$(^{87}Sr/^{86}Sr)_i$	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	2σ	T_{CHUR}(Ga)	T_{DM}(Ga)	$(^{143}Nd/^{144}Nd)_i$	$\varepsilon_{Nd}(t)$
East Purang													
LAC-7	dolerite	0.124	0.08589	0.70311	0.000009	0.70295	0.21481	0.51311	0.000005	3.92	-5.39	0.51293	8.9
LAC-9	dolerite	0.124	0.04608	0.70333	0.000010	0.70325	0.21059	0.51312	0.000006	5.22	1.57	0.51295	9.2
LAC-31	dolerite	0.124	0.01802	0.70362	0.000007	0.70359	0.22206	0.51310	0.000006	2.74	-0.98	0.51292	8.6
CMN-27	dolerite	0.125	0.01495	0.70621	0.000014	0.70618	0.19595	0.51309	0.000005	-139.91	0.55	0.51293	8.8
CMN-30	dolerite	0.125	0.01351	0.70477	0.000010	0.70475	0.20912	0.51304	0.000006	4.89	3.70	0.51287	7.7
West Purang													
JYM-4	dolerite	0.139	0.33403	0.70689	0.000007	0.70623	0.10579	0.51244	0.000004	0.34	1.01	0.51234	-2.3
JYM-5	dolerite	0.139	0.28488	0.70691	0.000009	0.70635	0.10897	0.51244	0.000005	0.35	1.04	0.51234	-2.4
JYM-15	dolerite	0.139	0.32369	0.70662	0.000010	0.70598	0.10669	0.51242	0.000005	0.37	1.04	0.51232	-2.6
JYM-24	dolerite	0.139	0.21495	0.70661	0.000007	0.70618	0.11145	0.51243	0.000006	0.38	1.08	0.51233	-2.6
JYM-39	dolerite	0.139	0.17704	0.70800	0.000009	0.70765	0.10181	0.51242	0.000005	0.36	1.00	0.51232	-2.6

Supplementary file 4a. Zircon LA-ICP-MS U-Pb isotopic data of the west (sample JYM-24) and east (sample LAC-31 and CMN-30) Purang dolerites.

Spots	Th/U	Pb	Th	U	Common Pb	$^{207}Pb/^{206}Pb$ Ratio	2σ	$^{207}Pb/^{235}U$ Ratio	2σ	$^{206}Pb/^{238}U$ Ratio	2σ	$^{207}Pb/^{235}U$ Age (Ma)	2σ	$^{206}Pb/^{238}U$ Age (Ma)	2σ
		ppm													
East Purang dolerites															
LAC-31-1	0.9	2.4	82.0	93.2	0.0	0.08266	0.02202	0.19188	0.04724	0.01872	0.00125	178.2	40	119.5	8
LAC-31-2	0.8	2.7	76.1	93.4	0.0	0.08197	0.01694	0.21983	0.04289	0.02049	0.00111	201.8	36	130.8	7
LAC-31-3	0.4	3.4	31.7	71.6	1.7	0.08571	0.01516	0.23594	0.04580	0.01924	0.00067	215.1	38	122.8	4
LAC-31-4	0.8	3.3	83.1	103	1.5	0.08549	0.01137	0.22207	0.02927	0.01875	0.00062	203.6	24	119.8	4
LAC-31-5	0.5	1.9	37.1	71.4	0.0	0.10906	0.02605	0.27933	0.06691	0.01952	0.00142	250.1	53	124.6	9
LAC-31-6	0.9	2.3	77.7	86.6	0.0	0.07854	0.01985	0.19196	0.04708	0.01901	0.00133	178.3	40	121.4	8
LAC-31-7	0.7	3.2	47.7	67.4	0.0	0.10106	0.05564	0.19496	0.06391	0.01977	0.00174	180.8	54	126.2	11
LAC-31-8	0.6	1.3	30.4	50.8	1.3	0.09522	0.03309	0.24364	0.09234	0.01973	0.00182	221.4	75	125.9	12
LAC-31-9	0.9	4.7	76.4	86.3	1.1	0.05303	0.01497	0.13372	0.03280	0.02017	0.00126	127.4	29	128.7	8
LAC-31-10	0.6	3.9	57.7	98.1	2.2	0.06614	0.01027	0.17840	0.02329	0.02049	0.00095	166.7	20	130.7	6
LAC-31-11	0.7	4.7	83.2	118	0.0	0.07480	0.01069	0.20319	0.02722	0.01965	0.00078	187.8	23	125.5	5
LAC-31-12	0.4	20.2	331	806	1.2	0.07726	0.00723	0.21523	0.02079	0.01972	0.00066	197.9	17	125.9	4
LAC-31-13	0.7	2.0	54.9	80.4	0.0	0.09141	0.02304	0.21734	0.04439	0.01899	0.00145	199.7	37	121.3	9
LAC-31-14	1.0	2.9	98.7	100	0.0	0.06800	0.01595	0.18011	0.03897	0.01997	0.00144	168.2	34	127.5	9
LAC-31-15	0.9	2.5	83.3	94.7	1.8	0.05815	0.01521	0.15536	0.04561	0.01924	0.00131	146.6	40	122.8	8
CMN-30-1	1.9	14.8	932	479	2.8	0.06426	0.01405	0.15486	0.02744	0.01946	0.00203	146.2	24	124.2	13
CMN-30-2	2.0	17.5	1073	528	0.0	0.05860	0.00687	0.15436	0.01708	0.01921	0.00054	145.8	15	122.6	3
CMN-30-3	0.9	12.5	410	471	0.6	0.06578	0.00691	0.17554	0.01885	0.01924	0.00064	164.2	16	122.9	4
CMN-30-4	2.4	31.0	2041	846	1.3	0.06404	0.00704	0.17067	0.01695	0.01958	0.00052	160.0	15	125.0	3
CMN-30-5	1.8	21.6	1133	623	4.3	0.08151	0.01061	0.22613	0.03432	0.01958	0.00064	207.0	28	125.0	4
CMN-30-6	1.3	16.8	750	590	1.0	0.05538	0.00642	0.14692	0.01588	0.01946	0.00060	139.2	14	124.2	4

CMN-30-7	2.2	13.4	886	406	0.0	0.05660	0.00844	0.15299	0.02235	0.01959	0.00075	144.5	20	125.0	5
CMN-30-8	2.2	2.9	187	83.3	1.3	0.06386	0.01430	0.17368	0.03465	0.02007	0.00110	162.6	30	128.1	7
CMN-30-9	1.3	19.1	801	640	1.4	0.05616	0.00638	0.15472	0.01655	0.01961	0.00056	146.1	15	125.2	4
CMN-30-10	3.3	16.0	1392	423	1.7	0.05444	0.01124	0.13944	0.02870	0.01912	0.00135	132.5	26	122.1	9
CMN-30-11	2.5	21.3	1461	583	1.7	0.04734	0.00673	0.13302	0.01736	0.01973	0.00064	126.8	16	125.9	4
Wast Purang dolerites															
JYM-24-1	1.7	75.0	3638	2147	0.0	0.04662	0.00391	0.14258	0.01184	0.02181	0.00064	135.3	11	139.1	4
JYM-24-2	0.9	73.3	2134	2494	2.1	0.04748	0.00352	0.14456	0.01086	0.02170	0.00054	137.1	10	138.4	3
JYM-24-3	1.2	109	4161	3518	2.5	0.04782	0.00357	0.14603	0.01063	0.02187	0.00058	138.4	9	139.5	4
JYM-24-4	1.0	122	3948	4088	0.0	0.04632	0.00344	0.13894	0.00986	0.02148	0.00057	132.1	9	137.0	4
JYM-24-5	1.1	54.9	2038	1882	0.0	0.04619	0.00414	0.13956	0.01234	0.02162	0.00066	132.7	11	137.9	4
JYM-24-6	1.5	120	6053	3996	1.5	0.04650	0.00555	0.13883	0.02003	0.02107	0.00116	132.0	18	134.4	7
JYM-24-7	1.5	114	5136	3325	1.6	0.04694	0.00461	0.14183	0.01396	0.02160	0.00087	134.7	12	137.8	5
JYM-24-8	1.8	86.6	4422	2439	0.8	0.04953	0.00497	0.15283	0.01497	0.02186	0.00062	144.4	13	139.4	4
JYM-24-9	1.4	75.9	3219	2288	0.0	0.04724	0.00484	0.14643	0.01471	0.02204	0.00067	138.8	13	140.5	4
JYM-24-10	2.4	114	6746	2803	0.6	0.04625	0.00474	0.14428	0.01505	0.02210	0.00076	136.9	13	140.9	5
JYM-24-11	2.6	90.7	5692	2232	0.9	0.04660	0.00433	0.14171	0.01339	0.02168	0.00067	134.6	12	138.3	4
JYM-24-12	1.5	120	5277	3456	0.2	0.04848	0.00491	0.14831	0.01708	0.02174	0.00071	140.4	15	138.6	5
JYM-24-13	2.0	149	7909	4048	0.0	0.04671	0.00313	0.14301	0.01033	0.02185	0.00069	135.7	9	139.3	4
JYM-24-14	0.9	91.6	2673	3027	0.0	0.04916	0.00336	0.14782	0.01051	0.02169	0.00051	140.0	9	138.3	3
JYM-24-15	1.9	137	7357	3937	2.4	0.04891	0.00636	0.14363	0.01846	0.02127	0.00078	136.3	16	135.7	5
JYM-24-16	1.7	69.0	3298	1928	0.0	0.04810	0.00354	0.14397	0.01076	0.02168	0.00054	136.6	10	138.3	3

Supplementary file 4b. U-Pb isotopic data of the Standard zircons (Temora and Qinghu).

Sample	Pb	Th	U	Common Pb	$^{207}Pb/^{206}Pb$	2σ	$^{207}Pb/^{235}U$	2σ	$^{206}Pb/^{238}U$	2σ	$^{207}Pb/^{235}U$	2σ	$^{206}Pb/^{238}U$	2σ
	ppm				Ratio		Ratio		Ratio		Age (Ma)		Age (Ma)	
Temora zircons, n=20, weighted mean age: 416. 8±6.3, MSWD = 0.00046.														
Temorastd-1	16.7	43.0	220	0.1	0.05318	0.00601	0.48816	0.05279	0.06681	0.00210	403.7	36	416.9	13
Temorastd-2	10.3	66.8	123	0.0	0.05722	0.00752	0.52744	0.06738	0.06679	0.00254	430.1	45	416.8	15
Temorastd-3	13.9	84.9	162	0.0	0.05519	0.00637	0.51111	0.06168	0.06678	0.00248	419.2	41	416.7	15
Temorastd-4	3.4	16.1	41.4	0.0	0.05178	0.01256	0.46778	0.10312	0.06682	0.00338	389.7	71	417.0	20
Temorastd-5	4.0	24.5	50.5	0.0	0.05603	0.01312	0.50502	0.10506	0.06680	0.00348	415.1	71	416.8	21
Temorastd-6	5.7	19.0	74.0	0.0	0.05437	0.01116	0.51058	0.09527	0.06680	0.00313	418.8	64	416.9	19
Temorastd-7	12.0	84.8	142	0.0	0.05866	0.00795	0.54125	0.07163	0.06677	0.00269	439.2	47	416.7	16
Temorastd-8	5.5	22.6	69.0	0.0	0.05441	0.01166	0.49543	0.10040	0.06668	0.00323	408.6	68	416.1	20
Temorastd-9	11.9	74.8	138	0.5	0.05479	0.00733	0.50225	0.06593	0.06676	0.00219	413.2	45	416.6	13
Temorastd-10	50.4	388	557	0.0	0.05561	0.00441	0.51335	0.03946	0.06684	0.00161	420.7	26	417.1	10
Temorastd-11	12.6	31.4	165	0.0	0.05373	0.00599	0.49777	0.05698	0.06679	0.00206	410.2	39	416.8	12
Temorastd-12	20.4	114	250	0.0	0.05589	0.00693	0.51690	0.06143	0.06682	0.00219	423.1	41	417.0	13
Temorastd-13	13.5	82.0	162	0.6	0.04946	0.00651	0.45741	0.05684	0.06686	0.00229	382.5	40	417.2	14
Temorastd-14	4.1	18.3	49.5	0.0	0.06094	0.01064	0.55819	0.09182	0.06674	0.00301	450.3	60	416.5	18
Temorastd-15	14.9	75.9	190	0.0	0.05422	0.00673	0.50039	0.05760	0.06676	0.00208	412.0	39	416.6	13
Temorastd-16	4.0	22.0	49.6	0.0	0.06203	0.01313	0.56374	0.11035	0.06676	0.00316	454.0	72	416.6	19
Temorastd-17	10.0	44.9	125	0.1	0.05009	0.00787	0.46456	0.07002	0.06669	0.00272	387.4	49	416.2	16
Temorastd-18	26.9	180	299	0.1	0.05565	0.00501	0.51264	0.04539	0.06678	0.00192	420.2	30	416.7	12
Temorastd-19	15.3	70.8	193	0.0	0.05476	0.00617	0.50094	0.05716	0.06671	0.00238	412.3	39	416.3	14
Temorastd-20	12.6	74.4	155	0.0	0.05564	0.00649	0.51466	0.06152	0.06689	0.00231	421.6	41	417.4	14
Qinghu zircons, n=10, weighted mean age: 154.8±2.9, MSWD = 0.49.														

Qinghu-1	42.5	775	1481	0.6	0.04695	0.00424	0.15291	0.01376	0.02358	0.00066	144.5	12	150.2	4
Qinghu-2	32.1	464	1071	0.0	0.04925	0.00446	0.16556	0.01481	0.02440	0.00074	155.6	13	155.4	5
Qinghu-3	30.1	573	1004	0.3	0.05001	0.00672	0.17163	0.02144	0.02441	0.00084	160.8	19	155.5	5
Qinghu-4	35.5	543	1210	0.3	0.04988	0.00449	0.16638	0.01458	0.02386	0.00072	156.3	13	152.0	5
Qinghu-5	30.2	534	1007	0.0	0.05116	0.00599	0.17363	0.02008	0.02449	0.00075	162.6	17	156.0	5
Qinghu-6	37.5	432	1317	0.3	0.04834	0.00439	0.16218	0.01417	0.02423	0.00069	152.6	12	154.3	4
Qinghu-7	13.8	236	447	0.0	0.05409	0.00647	0.18801	0.02176	0.02503	0.00077	174.9	19	159.3	5
Qinghu-8	20.5	362	668	0.0	0.04759	0.00612	0.16625	0.01995	0.02535	0.00082	156.2	17	161.4	5
Qinghu-9	32.1	462	1119	1.0	0.04890	0.00593	0.16343	0.01916	0.02390	0.00083	153.7	17	152.3	5
Qinghu-10	29.9	584	963	0.6	0.04604	0.00415	0.15234	0.01323	0.02421	0.00070	144.0	12	154.2	4

Supplementary file 5. Zircon REE data of the west (sample JYM-24) and east (sample LAC-31 and CMN-30) Purang dolerites.

Spots	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
East Purang dolerites														
LAC-31-1	0.11	14.2	0.95	12.5	17.6	10.7	84.4	26.3	292	104	447	94.9	911	183
LAC-31-2	0.10	11.4	0.70	9.49	14.2	8.95	68.4	22.5	262	96.1	428	91.5	901	189
LAC-31-3	0.03	3.76	0.17	2.52	4.30	3.05	23.6	8.19	106	43.9	217	52.1	554	127
LAC-31-4	0.06	11.8	0.67	9.22	13.9	9.73	70.7	23.9	281	104	466	103	1021	206
LAC-31-5	0.04	4.33	0.19	2.38	5.51	3.63	29.8	10.4	127	50.5	240	55.0	577	126
LAC-31-6	0.10	13.7	0.87	11.6	18.4	10.8	87.0	28.3	325	115	503	108	1053	208
LAC-31-7	0.08	5.52	0.28	3.45	6.68	4.77	31.9	11.1	127	48.1	222	48.9	495	109
LAC-31-8	0.13	4.99	0.18	3.18	5.46	3.70	29.3	10.0	123	49.6	235	54.4	557	123
LAC-31-9	0.08	12.1	0.65	9.84	17.7	10.8	85.6	27.9	323	118	516	110	1076	219
LAC-31-10	0.05	6.49	0.33	4.23	7.50	5.27	39.1	13.4	165	65.0	301	66.3	677	143
LAC-31-11	0.08	8.84	0.43	7.20	12.1	7.49	64.3	22.4	269	103	462	101	1004	211
LAC-31-12	0.07	4.76	0.09	1.24	3.04	1.92	26.2	9.61	132	58.2	289	67.3	734	175
LAC-31-13	0.04	8.56	0.44	6.08	10.9	6.52	56.8	19.3	226	85.4	381	85.1	837	177
LAC-31-14	0.14	15.3	1.05	15.7	21.5	12.7	95.0	28.1	314	107	454	93.8	893	178
LAC-31-15	0.19	13.7	1.01	13.5	17.5	11.2	82.8	26.3	290	105	447	94.8	930	186
CMN-30-1	0.33	187	2.40	43.2	109	2.60	648	218	2334	746	2986	572	5116	901
CMN-30-2	0.63	38.6	0.70	8.49	15.4	2.03	127	53.4	772	339	1710	389	3779	741
CMN-30-3	0.54	193	2.96	55.6	130	2.49	714	206	1923	553	2056	376	3284	563
CMN-30-4	0.40	439	6.32	116	228	4.25	1031	271	2283	645	2441	467	4279	804
CMN-30-5	0.18	17.6	0.33	4.60	10.8	2.05	93.9	37.8	527	241	1276	313	3233	694
CMN-30-6	0.15	76.4	0.58	9.92	27.5	2.18	221	76.9	922	349	1567	351	3426	692
CMN-30-7	0.65	400.1	7.50	138	328	5.25	1702	526	5182	1457	5119	890	7158	1146

CMN-30-8	0.09	46.6	1.02	17.6	40.0	3.52	229	75.6	831	300	1294	267	2422	477
CMN-30-9	0.69	33.9	1.31	13.0	20.5	2.50	125	45.7	577	233	1168	274	2754	578
CMN-30-10	0.25	147	1.83	31.1	73.4	4.34	402	127	1334	444	1868	368	3122	572
CMN-30-11	0.60	944	12.0	229	487	6.24	2271	614	5171	1226	3701	587	4450	647
Wast Purang dolerites														
JYM-24-1	1.35	110	5.13	55.6	55.2	8.36	200.4	61.7	685	227	926	172	1346	190
JYM-24-2	1.22	42.7	1.56	17.4	21.6	2.40	99.3	34.3	426	164	733	145	1171	179
JYM-24-3	1.41	132	4.42	49.9	51.5	9.86	192	62.9	716	251	1047	197	1524	218
JYM-24-4	0.24	47.4	0.93	12.1	14.6	1.62	67.4	23.5	292	113	513	104	864	139
JYM-24-5	1.30	73.7	2.41	23.5	24.7	5.09	107	39.2	496	188	858	177	1476	219
JYM-24-6	0.96	50.5	1.90	19.9	22.1	5.02	84.6	29.3	348	132	583	114	864	123
JYM-24-7	1.05	59.0	1.31	15.4	18.5	6.48	87.0	31.1	400	158	720	148	1121	163
JYM-24-8	0.93	137	5.65	63.1	64.2	2.51	231	75.8	833	283	1140	213	1600	223
JYM-24-9	1.50	107	4.47	44.5	43.8	5.11	163	54.5	599	200	794	145	1094	154
JYM-24-10	1.02	83.9	2.88	31.5	33.2	7.72	138	45.6	530	198	868	170	1301	193
JYM-24-11	4.31	258	15.7	164	152	2.85	492	143	1454	468	1834	319	2412	362
JYM-24-12	1.72	68.7	2.61	27.9	27.7	3.43	113	39.5	473	181	804	160	1262	186
JYM-24-13	0.31	62.2	1.76	22.6	29.0	2.53	132	45.5	538	207	892	171	1303	191
JYM-24-14	0.81	67.7	2.52	28.7	29.5	2.64	119	42.3	496	182	793	158	1251	185
JYM-24-15	2.56	77.1	2.41	19.3	16.7	5.58	74.1	25.2	290	114	511	101	775	115
JYM-24-16	0.84	92.4	3.31	34.8	37.8	5.60	155.5	54.4	643	243	1064	218	1812	289

Supplementary file 6a. Lu-Hf isotopic compositions for zircons of the west and east Purang dolerites.

No.	Age (Ma)	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2σ	$^{176}Hf/^{177}Hf_i$	$e_{Hf}(t)$	T_{DM} (Ma)	T_{DM}^C (Ma)
East purang dolerites								
LAC-31-1	119.5	0.006262	0.282922	0.000044	0.282908	7.5	543	701
LAC-31-2	130.8	0.006439	0.282903	0.000047	0.282887	6.9	579	742
LAC-31-3	122.8	0.003170	0.283006	0.000042	0.282998	10.7	370	495
LAC-31-4	119.8	0.004678	0.282972	0.000034	0.282961	9.3	440	581
LAC-31-5	124.6	0.004978	0.282805	0.000044	0.282793	3.5	709	958
LAC-31-6	121.4	0.003337	0.282990	0.000027	0.282983	10.1	395	531
LAC-31-7	126.2	0.001888	0.283115	0.000022	0.283111	14.8	197	237
LAC-31-8	125.9	0.003413	0.282999	0.000027	0.282991	10.5	383	509
LAC-31-9	128.7	0.001842	0.283074	0.000028	0.283070	13.4	257	329
LAC-31-10	130.7	0.001800	0.283024	0.000024	0.283019	11.6	330	443
LAC-31-11	125.5	0.005123	0.283003	0.000037	0.282991	10.5	397	511
LAC-31-12	125.9	0.002070	0.283029	0.000021	0.283024	11.7	324	434
LAC-31-13	121.3	0.003779	0.282949	0.000034	0.282940	8.6	464	628
LAC-31-14	127.5	0.005090	0.283035	0.000032	0.283023	11.7	344	436
LAC-31-15	122.8	0.004768	0.282848	0.000045	0.282837	5.0	637	860
CMN-30-1	124.2	0.008919	0.283072	0.000077	0.283051	12.6	322	374
CMN-30-2	122.6	0.011265	0.283154	0.000040	0.283128	15.3	190	201
CMN-30-3	122.9	0.008572	0.283180	0.000049	0.283161	16.4	125	126
CMN-30-4	125.0	0.011854	0.283159	0.000062	0.283131	15.4	184	192
CMN-30-5	125.0	0.008542	0.283201	0.000051	0.283181	17.2	88	78
CMN-30-6	124.2	0.009514	0.283168	0.000043	0.283145	15.9	153	159
CMN-30-7	125.0	0.014816	0.283209	0.000053	0.283174	17.0	93	93
CMN-30-8	128.1	0.010253	0.283198	0.000042	0.283174	17.0	99	93
CMN-30-9	125.2	0.008790	0.283143	0.000051	0.283123	15.2	192	210
CMN-30-10	122.1	0.012065	0.283149	0.000052	0.283121	15.0	205	216
CMN-30-11	125.9	0.012587	0.283089	0.000066	0.283060	12.9	332	354
West purang dolerites								
JYM-24-1	139.1	0.004561	0.282816	0.000030	0.282804	4.2	683	924
JYM-24-2	138.4	0.004336	0.282799	0.000028	0.282788	3.6	704	960
JYM-24-3	139.5	0.004265	0.282808	0.000023	0.282797	3.9	690	940
JYM-24-4	137.0	0.003734	0.282774	0.000026	0.282765	2.7	730	1013
JYM-24-5	137.9	0.004025	0.282800	0.000028	0.282790	3.7	696	956
JYM-24-6	134.4	0.003453	0.282771	0.000042	0.282762	2.6	729	1021
JYM-24-7	137.8	0.003648	0.282771	0.000038	0.282761	2.6	734	1020
JYM-24-8	139.4	0.003801	0.282776	0.000031	0.282766	2.9	728	1008
JYM-24-9	140.5	0.003866	0.282787	0.000028	0.282776	3.2	714	985
JYM-24-10	140.9	0.005747	0.282806	0.000047	0.282791	3.8	724	952
JYM-24-11	138.3	0.006879	0.282793	0.000037	0.282776	3.2	770	988

JYM-24-12	138.6	0.004706	0.282828	0.000033	0.282815	4.6	667	898
JYM-24-13	139.3	0.005030	0.282785	0.000035	0.282771	3.0	742	997
JYM-24-14	138.3	0.004358	0.282816	0.000029	0.282805	4.2	678	922
JYM-24-15	135.7	0.004190	0.282807	0.000033	0.282796	3.8	689	943
JYM-24-16	138.3	0.004660	0.282818	0.000026	0.282806	4.2	681	920

Note: ε_{Hf} , $f_{Lu/Hf}$, T_{DM} are defined as: $\varepsilon_{Hf}(0) = ((^{176}Hf/^{177}Hf)_S/(^{176}Hf/^{177}Hf)_{CHUR,0} - 1)\times 10,000$, $\varepsilon_{Hf}(t) = (((^{176}Hf/^{177}Hf)_S - (^{176}Lu/^{176}Hf)_S \times (e^{\lambda t} - 1))/((^{176}Hf/^{177}Hf)_{CHUR,0} - (^{176}Lu/^{177}Hf)_{CHUR} \times (e^{\lambda t} - 1)) - 1)\times 10,000$, $f_{Lu/Hf} = (^{176}Lu/^{177}Hf)_S/(^{176}Lu/^{177}Hf)_{CHUR} - 1$, where $(^{176}Lu/^{177}Hf)_S$ and $(^{176}Hf/^{177}Hf)_S$ are the measured values of samples, $(^{176}Lu/^{177}Hf)_{CHUR} = 0.0332$ and $(^{176}Hf/^{177}Hf)_{CHUR,0} = 0.282772$(Blichert-Toft and Albarède, 1997); $T_{DM} = 1/\lambda \times \ln(1 + ((^{176}Hf/^{177}Hf)_S - (^{176}Hf/^{177}Hf)_{DM})/((^{176}Lu/^{177}Hf)_S - (^{176}Lu/^{177}Hf)_{DM}))$. $\lambda = 1.865 \times 10^{-11}$/y (Soderlund et al., 2004), and t = crystallization age of zircon.

Supplementary file 6b. Lu-Hf isotopic compositions for Standard zircons (GJ-1, 91500 and Penglai)

Sample	$^{176}Lu/^{177}Hf$	$^{176}Hf/^{177}Hf$	2σ
GJ-1-1	0.000251	0.282002	0.000025
GJ-1-2	0.000249	0.282024	0.000022
GJ-1-3	0.000249	0.282014	0.000019
GJ-1-4	0.000250	0.282012	0.000022
GJ-1-5	0.000253	0.282018	0.000024
GJ-1-6	0.000248	0.282009	0.000022
GJ-1-7	0.000250	0.282019	0.000022
91500-1	0.000371	0.282298	0.000024
91500-2	0.000377	0.282304	0.000021
91500-3	0.000367	0.282318	0.000023
91500-4	0.000376	0.282299	0.000021
Penglai-1	0.000241	0.282904	0.000022
Penglai-2	0.000244	0.282899	0.000023
Penglai-3	0.000244	0.282902	0.000021
Penglai-4	0.000252	0.282919	0.000023

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