In-situ oxygen isotope records of crustal self-cannibalization selectively captured by zircon crystals from high-δ^{26}Mg granitoids

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ANALYTICAL METHODS

Oxygen isotopic analysis: Zircon oxygen isotopes were measured using a Cameca IMS 1280 ion probe at the SIMS laboratory of the Institute of Geology and Geophysics, Chinese Academy of Sciences in Beijing. The Gaussian focused Cs^+ primary ion beam was accelerated at 10 kV with an intensity of 2.5–3 nA. The spot size was approximately 20 µm in diameter (10 µm beam + 10 µm raster). A normal incidence electron flood gun was used to compensate for sample charging. The magnetic field was stabilized by using a nuclear magnetic resonance controller. Negative secondary ions were extracted with a –10 kV potential. The field aperture was 5000 × 5000 µm^2. A 125 µm entrance slit, 30 eV energy slit, and 500 µm exit slit provide a mass resolution of ~2500 at 1% peak height. The intensity of ^{16}O was typically 2 × 10^9 cps. The ^{16}O and ^{18}O ions were detected simultaneously by two Faraday cups with 10^{10} and 10^{11} Ω resistors, respectively. One analysis consists of pre-sputtering (~20 s), automatic beam centering (~60 s) and integration of oxygen isotopes (25 cycles × 4 s), leading to complete analysis within approximately 4 minutes. The in-run precision was typically better than 0.2‰ (2SE). Measured ^{18}O/^{16}O ratios were normalized to Vienna standard mean oceanic water (VSMOW, ^{18}O/^{16}O = 0.0020052, Baertschi, 1976) and presented as δ^{18}O notation. The instrumental mass fractionation (IMF) was corrected using the FC1 zircon (δ^{18}O = 5.4±0.3 ‰, Ickert et al., 2008). The spot-to-spot reproducibility of FC1 zircon for a single analytical session ranged from 0.26‰ to 0.07‰ (1SD). The 91500 zircon yielded an average IMF-corrected δ^{18}O of 9.69±0.18 ‰ (n = 39, 1SD), which is consistent with the recommended value of 9.9±0.3 ‰ (Wiedenbeck et al., 2004) within uncertainty.

U-Pb geochronology: Zircon U-Th-Pb isotopes were measured using the SHRIMP IIe/MC at the Korea Basic Science Institute. A 2–4 nA mass filtered O_2^- primary beam was focused to a spot of ca. 25 µm diameter on the polished surface of zircon with 10 kV accelerating voltage. Each spot was rastered with the primary beam for 180 seconds prior to the analysis, and then analyzed five cycles with a single electron multiplier. During one cycle, the magnet was stepped through peaks of $^{90}Zr_2{}^{16}O$ (integration time = 2 s), ^{204}Pb (10 s), ^{206}Pb (10 s), ^{207}Pb (20 s), ^{208}Pb (5 s), ^{238}U (5 s), $^{232}Th^{16}O$ (2 s) and $^{238}U^{16}O$ (2 s). The collector slit was fixed at 100 μm in width, achieving a mass resolution of about 5000 at 1% peak height. FC1 (1099 Ma; Paces and Miller, 1993) and SL13 (U = 238 ppm) standard zircons were used for Pb/U calibration and U abundances, respectively. Pb/U ratios were calibrated against FC1 using its power law relationship between Pb^+/U^+ and UO^+/U^+, while Th/U ratios were estimated using a fractionation factor derived from the measured $^{232}Th^{16}O^+/^{238}U^{16}O^+$ versus $^{208}Pb/^{206}Pb$ of the SL13 standard. Common Pb was removed by the ^{207}Pb (for spots < 1000 Ma) or ^{204}Pb (for spots > 1000 Ma) correction method using the model by Stacy and Kramers (1975). Data processing was conducted using SQUID 2.50 and Isoplot 3.75 programs (Ludwig, 2008, 2009). Spots having high U concentrations (> 2000 ppm) were not considered in the age calculation.

Lu-Yb-Hf isotopic analysis: Zircon Lu-Yb-Hf isotopic compositions were analyzed using a Nu Plasma II MC-ICPMS combined with a 193 nm ArF excimer laser ablation system at the Korea Basic Science Institute. Laser ablation was targeted for the analyzed points for oxygen and U-Th-Pb isotopes or new points within the same cathodoluminescence domains. Some of the spots were not analyzed because of technical issues, such as the domain size or the presence of microcracks or inclusions. Laser ablation parameters were as follows: Pulse energy density, 8–13 J/cm^2; repetition rate, 8–15 Hz; total ablation time, ~60 s; crater diameter, 35–50 μm. During laser firing, the sample stage automatically moved up to reduce ablation-related downhole fractionation. A small amount of helium was added to the argon carrier gas. The mixed gas flow rate was between 0.6 and 0.8 L/min in a Truline cell. Ten isotopes (at masses 172–180 and 182) were simultaneously measured on fixed Faraday cups. The operation conditions were as follows: RF forward power, 1300 W; reflected power, <1 W; auxiliary Ar gas flow rate, 0.8 L/min; cool Ar gas flow rate, 13 L/min; integration time, 0.4 s. The data were acquired in a time-resolved analysis mode. The Yb and Lu isotopic compositions employed for the correction of mass bias and isobaric interference were adopted from Vervoort et al. (2004) and Chu et al. (2002), respectively. The isobaric interference-corrected $^{176}Hf/^{177}Hf$ ratios were exponentially normalized to $^{179}Hf/^{177}Hf$ = 0.7325. The $^{176}Lu/^{177}Hf$ and $^{176}Yb/^{177}Hf$ ratios were calculated after Iizuka and Hirata (2005). Initial epsilon Hf values were calculated using a ^{176}Lu decay constant of 1.865×10^{-11} $year^{-1}$ (Scherer et al., 2001) and the chondritic values suggested by Blichert-Toft and Albarade (1997). Single- (T_{DM}) and two-stage model ages (T_{2DM}) were calculated with reference to suggested parameters for depleted mantle (Griffin et al., 2000) and average continental crust (Rudnick and Gao, 2005). Data reduction was carried out using Iolite 2.5 running within Wave metrics Igor Pro (Paton et al., 2011). During the sample analysis, the 91500 and FC1 zircons respectively yielded average $^{176}Hf/^{177}Hf$ ratios of 0.282294 ± 0.000006 (n = 54, 2SE) and 0.282171 ± 0.000006 (n = 50, 2SE), which agree well with the recommended values in the literature (Griffin et al., 2000; Woodhead et al., 2004; Kemp et al., 2010).

Mg isotopic analysis: Mineral separation, chemical purification, and mass spectrometry were carried out at the Korea Basic Science Institute. Crushed rock samples were sieved to a size range of 245−850 μm. Fresh biotite grains with no visible alteration were handpicked under a binocular microscope, and then cleaned with 18 MΩ Milli-Q water in an ultrasonic bath. Biotite grains were completely digested in a 5:3 mixture of HF and HNO_3 in Teflon beakers. The sample solution was dried, refluxed several times in 6 M HCl to remove fluorides, and finally re-dissolved in 0.4 M HCl. Mg was purified using an AG-50W-X8 resin (200–400 mesh). After loading the sample, matrix elements were eluted with 5 mL of 0.15 M HF, followed by 10 mL of the mixture of 0.5 M HCl and 95% acetone and 8 mL of 1 M HNO_3

before collecting Mg in 12 mL of 1 M HNO_3. Magnesium isotope ratios were measured using a Neptune MC-ICPMS upgraded with a large dry interface pump. Samples were introduced using a quartz dual cyclonic spray chamber and analyzed with a standard-sample-standard bracketing method. Sample intensities were matched to within 10% of the intensity of the standard. Using the Jet sample cone and X-skimmer cone, the sensitivity was ~80 V/ppm on mass 24 at a typical uptake rate of 100 μL/min. Prior to isotopic analysis, each sample was checked for yield and the concentration of matrix elements (Al, Ca, Fe, K, Mn, Na, and Ti). Mg yields were about 100% and the matrix concentration did not exceed 1% of the Mg concentrations. The total procedural blanks were negligible with less than 3 ng of Mg. All $^{26}Mg/^{24}Mg$ and $^{25}Mg/^{24}Mg$ ratios are reported in delta notation relative to DSM-3, where $\delta^{x}Mg = [(^{x}Mg/^{24}Mg)_{sample}/(^{x}Mg/^{24}Mg)_{DSM\text{-}3} - 1] \times 1000$ and x = 25 or 26. Samples were analyzed in replicate (n = 3–8), where uncertainties were reported as two standard deviations. Three reference materials (DSM-3, CAM-1, and SRM980) were repeatedly measured during the period of analysis. Measured $\delta^{26}Mg$ for DSM-3 (–0.01±0.06 ‰, 2σ, n = 408), CAM-1 (–2.62±0.06 ‰, 2σ, n = 404), and SRM980 (–4.32±0.09 ‰, 2σ, n = 249) were all in good agreement with reported values (see Table DR4; e.g., Galy et al., 2001, 2003; Brenot et al., 2008; Tipper et al., 2008; Huang et al., 2009). The chemical purification, and the precision and accuracy of Mg isotope measurements were validated using the USGS powder standards (BIR-1, GSP-2, and MAG-1) (see Table DR4; e.g., Teng et al., 2007; Tipper et al., 2008; Huang et al., 2009; Wombacher et al., 2009; Bizzarro et al., 2011; Opfergelt et al., 2012; An et al., 2014). When plotted as $\delta^{25}Mg$ versus $\delta^{26}Mg$, the samples analyzed in this study gave a line with a slope of 0.517±0.004 (2σ), which lies between the theoretical equilibrium slope of 0.521 and the theoretical kinetic slope of 0.511 (Young and Galy, 2004). All samples analyzed in this study yielded $\Delta^{25}Mg'$ ($= \delta^{25}Mg' - 0.521 \times \delta^{26}Mg'$, $\delta^{x}Mg' = 1000 \times \ln[(\delta^{x}Mg + 1000)/1000]$) values between −0.02 and 0.03‰, indicating that there were no isobaric interferences after chemistry.

Raman spectroscopy: Raman spectra of zircon crystals from the Kwonyiri, Ijeonri, Namsan, and Gigye samples were collected at room-temperature by using a dispersive confocal DXR Raman microscope (Thermo Scientific) at the Tectonophysics Laboratory, Seoul National University. The spectra were built up using a laser system configured to use 5.0 mW of power and a laser wavelength of 532 nm under a 50× objective of an Olympus microscope with an automatic stage, resulting in a laser beam size of ca. 0.7 μm and a spectral resolution of 2.7−4.2 cm^{-1} over the wavenumber range of 100−1200 cm^{-1}. For data collection, the spectra were recorded with an exposure time of 4.0 s and 16 exposures. Two zircon standards (Penglai and 91500) were also measured for reference. Raman spectra obtained from these standard zircons were visibly indistinguishable from those documented in the literature (e.g., Gao et al., 2014) (see Fig. DR1).

TABLE DR1. Petrographic and mineralogic summary of granitoid samples, with GPS coordinates for sampling localities

Pluton name (Sample no.)	Latitude Longitude	Lithology	Texture	Mineralogy
Bangeojin (616-3)	35° 32' 57.8" 129° 27' 18.7"	Fine- to medium-grained biotite granite	Graphic texture	K-feldspar + Quartz + Plagioclase + Biotite ± Zircon ± Magnetite ± Monazite ± Ilmenite
Daejeonri (316-3)	35° 26' 36.0" 129° 21' 22.6"	Fine- to medium-grained hornblende-biotite granite	Micrographic texture	Quartz + Plagioclase + K-feldspar + Hornblende + Biotite ± Zircon ± Magnetite ± Ilmenite ± Monazite
Seosaeng (317-1)	35° 21' 17.2" 129° 20' 01.7"	Fine- to medium-grained hornblende granite	Compositional zoning pattern in plagioclase	Quartz + Plagioclase + K-feldspar + Hornblende + Biotite ± Zircon ± Magnetite ± Monazite ± Ilmenite ± Titanite
Kwonyiri (315-4)	35° 52' 02.7" 129° 25' 35.6"	Medium- to coarse-grained porphyritic granodiorite	Compositional zoning pattern in plagioclase	K-feldspar + Plagioclase + Quartz + Biotite ± Zircon ± Magnetite ± Monazite ± Ilmenite
Namsan (907-11)	35° 48' 23.0" 129° 13' 18.5"	Medium- to coarse-grained alkali granite	Graphic texture, interstitial biotite	K-feldspar + Quartz + Biotite ± Zircon ± Ilmenite ± Monazite
Ijeonri (616-7)	35° 38' 47.5" 129° 14' 00.2"	Medium- to coarse-grained biotite granite	Compositional zoning pattern in plagioclase	Quartz + Plagioclase + K-feldspar + Biotite + Hornblende ± Muscovite ± Monazite ± Titanite ± Magnetite ± Ilmenite
Gigye (906-4)	36° 07' 04.9" 129° 13' 19.0"	Medium- to coarse-grained porphyritic biotite granite	Compositional zoning pattern in plagioclase, graphic texture	Plagioclase + Quartz + Biotite ± Magnetite ± Ilmenite ± Titanite ± Zircon ± Apatite
Palgongsan (614-1)	35° 56' 57.7" 128° 47' 15.9"	Medium- to coarse-grained porphyritic biotite granite	Compositional zoning pattern in plagioclase, ocellus quartz, acicular apatite	Plagioclase + K-feldspar + Quartz + Biotite ± Magnetite ± Ilmenite ± Zircon ± Apatite

TABLE DR2. SHRIMP U-Th-Pb results for zircon

Spot number*	Common ^{206}Pb (%)	U (ppm)	Th (ppm)	Th/U	^{206}Pb/^{238}U	±†	^{207}Pb/^{206}Pb	±†	date (Ma)§	
Bangeojin (616-3)										
1-1.1$_r$		317	155	0.49	0.0086	3.2	0.0438	5.3	55.6	±1.6
1-2.1$_r$	0.70	304	201	0.66	0.0087	1.3	0.0521	6.0	55.8	±0.6
1-3.1$_r$		378	338	0.90	0.0089	4.1	0.0420	23.8	57.5	±2.0
1-4.1$_r$	1.73	471	261	0.55	0.0090	1.6	0.0423	6.0	58.3	±0.8
1-5.1$_r$	0.26	431	311	0.72	0.0089	2.2	0.0395	7.7	57.4	±1.1
1-6.1$_r$	0.03	488	191	0.39	0.0090	1.1	0.0457	4.0	57.7	±0.6
1-7.1$_r$	0.43	645	342	0.53	0.0090	1.6	0.0519	3.2	57.6	±0.9
1-8.1$_r$	1.21	138	152	1.10	0.0094	2.1	0.0554	23.7	59.6	±0.9
1-9.1$_{ic}$		1528	525	0.34	0.0103	0.9	0.0434	6.5	66.3	±0.6
1-9.2$_r$		528	362	0.68	0.0092	3.1	0.0602	19.0	57.8	±1.6
1-10.1$_c$	0.58	1689	802	0.47	0.0094	1.4	0.0389	3.2	61.1	±0.8
1-10.2$_r$	0.10	360	291	0.81	0.0089	2.2	0.0458	8.4	57.0	±1.0
1-12.1$_r$		377	188	0.50	0.0089	1.9	0.0402	5.7	57.7	±1.0
1-13.1$_r$	0.31	472	435	0.92	0.0087	2.1	0.0457	9.7	56.2	±1.0
1-14.1$_c$	0.48	2422	961	0.40	0.0094	0.9	0.0465	2.6	60.4	±0.5
1-14.2$_r$	0.03	266	206	0.77	0.0088	2.0	0.0475	16.5	56.4	±1.0
1-15.1$_r$	0.60	224	157	0.70	0.0085	5.7	0.0450	10.4	55.0	±2.7
1-16.1$_r$		487	245	0.50	0.0088	1.6	0.0437	4.6	56.7	±0.8
2-1.1$_c$	0.66	257	273	1.06	0.0090	5.3	0.0532	45.7	57.6	±2.2
2-1.2$_r$	0.16	360	321	0.89	0.0092	1.1	0.0607	7.2	58.3	±0.5
2-2.1$_c$	25.78	230	135	0.59	0.0087	3.1	0.0223	51.0	57.4	±1.1
2-2.2$_r$	0.09	2076	813	0.39	0.0096	0.7	0.0487	1.8	61.2	±0.4
2-3.1$_c$	0.02	287	754	2.62	0.0096	3.9	0.0704	152.9	59.7	±1.2
2-3.2$_r$		387	329	0.85	0.0093	1.8	0.0440	9.1	59.8	±0.9
2-4.1$_c$		148	199	1.35	0.0091	4.2	0.0501	45.3	57.9	±1.8
2-4.2$_r$		1083	329	0.30	0.0092	1.0	0.0443	2.7	59.6	±0.5
2-5.1$_c$		1669	5405	3.24	0.0099	2.8	0.0781	210.4	60.9	±0.6
2-5.2$_r$	0.11	370	305	0.82	0.0095	1.8	0.0474	8.2	60.8	±0.9
2-6.1$_c$		480	249	0.52	0.0099	1.6	0.0512	5.5	63.4	±1.0
2-6.2$_r$	0.47	490	256	0.52	0.0092	1.4	0.0573	3.6	58.4	±0.7
2-7.1$_c$	0.02	2313	854	0.37	0.0096	0.7	0.0487	1.7	61.6	±0.4
Daejeonri (316-3)										
1-2.1$_c$	0.77	149	219	1.47	0.0076	2.0	0.0511	46.3	48.7	±0.6
1-4.1$_c$	23.20	21	17	0.80	0.0074	7.3	0.0692	33.6	46.4	±1.9
1-5.2$_r$	10.44	55	49	0.90	0.0073	4.1	0.0600	21.8	46.1	±1.5
1-6.2$_r$	2.39	38	38	1.00	0.0076	1.8	0.0543	19.5	48.1	±0.6
1-7.1$_c$	4.38	19	19	1.00	0.0078	4.4	0.0476	40.0	49.8	±1.8
1-7.2$_r$	1.52	40	28	0.68	0.0075	2.6	0.0617	7.2	47.0	±1.0

1-8.1$_c$	4.39	11	5	0.46	0.0074	4.1	0.0388	20.0	47.9	±1.6
1-8.2$_r$	2.92	34	24	0.70	0.0077	3.3	0.0475	16.3	49.5	±1.2
1-9.1$_c$	5.53	17	16	0.94	0.0073	4.7	0.0508	30.9	46.6	±1.6
1-9.2$_r$	4.18	36	26	0.72	0.0077	1.6	0.0618	9.2	48.8	±0.6
1-10.1$_c$	4.75	15	12	0.80	0.0075	2.6	0.0447	26.1	48.6	±0.8
1-11.1$_r$	12.54	35	24	0.68	0.0074	3.4	0.0369	40.4	47.9	±1.4
1-12.1$_r$	1.07	81	83	1.02	0.0069	1.4	0.0501	16.8	44.3	±0.4
1-13.1$_r$	2.27	38	37	0.95	0.0078	3.4	0.0662	21.3	49.1	±1.2
1-14.1$_r$	2.67	51	46	0.90	0.0074	2.3	0.0437	17.1	47.8	±0.9
1-15.1$_r$	1.70	34	25	0.73	0.0077	2.3	0.0741	6.8	47.5	±0.9
1-16.1$_r$	1.92	35	29	0.84	0.0073	2.4	0.0444	17.2	46.9	±0.9
2-1.1$_c$		139	160	1.15	0.0073	3.6	0.0500	27.7	46.5	±1.3
2-2.1$_c$	6.22	66	74	1.13	0.0066	2.6	0.0473	82.4	42.2	±1.8
2-2.2$_r$	0.32	128	116	0.91	0.0073	3.2	0.0452	16.7	46.7	±1.2
2-3.1$_c$	0.17	32	24	0.75	0.0078	6.2	0.0624	22.8	49.4	±2.4
2-3.2$_r$		108	74	0.69	0.0073	1.9	0.0299	17.4	47.8	±0.7
2-4.1$_r$		129	103	0.80	0.0073	2.7	0.0480	11.9	46.8	±1.0
2-5.1$_c$	0.63	94	68	0.72	0.0078	2.9	0.0668	11.9	48.8	±1.3
2-5.2$_r$	0.36	153	124	0.81	0.0068	1.4	0.0465	13.0	43.9	±0.5
2-6.1$_{ic}$		1399	657	0.47	0.0118	1.3	0.0487	1.8	75.2	±0.9
2-6.2$_r$	0.01	115	70	0.61	0.0068	1.5	0.0461	9.8	44.0	±0.5
2-7.1$_c$	0.06	70	62	0.89	0.0074	2.8	0.0406	31.5	47.8	±1.1
2-7.2$_r$	0.12	247	244	0.99	0.0080	2.9	0.0495	12.6	51.1	±1.2
2-8.1$_c$	16.26	55	46	0.84	0.0073	5.4	0.0912	26.4	44.3	±1.4
2-9.1$_c$	0.13	371	800	2.16	0.0073	3.1	0.0407	129.2	47.2	±0.8
Seosaeng (317-1)										
1-1.1$_c$	0.90	349	325	0.93	0.0103	1.0	0.0429	9.9	66.7	±0.5
1-2.2$_r$	0.25	180	110	0.61	0.0110	1.1	0.0534	4.8	69.8	±0.7
1-3.1$_c$	0.06	423	455	1.08	0.0106	2.2	0.0462	11.3	68.0	±1.2
1-4.1$_c$		208	180	0.87	0.0108	1.6	0.0369	12.2	70.4	±0.9
1-4.2$_r$	0.78	104	58	0.56	0.0107	2.4	0.0524	7.3	67.9	±1.5
1-5.1$_c$	0.44	160	127	0.79	0.0110	1.2	0.0483	8.6	70.6	±0.7
1-6.1$_c$	1.30	264	228	0.87	0.0105	1.1	0.0455	8.9	67.6	±0.6
1-7.1$_c$	1.04	216	172	0.79	0.0110	2.1	0.0517	7.4	70.2	±1.2
1-8.1$_c$		427	624	1.46	0.0105	1.9	0.0408	30.7	67.6	±0.9
1-8.2$_r$	0.38	144	84	0.58	0.0108	2.6	0.0420	12.1	69.5	±1.7
1-9.1$_c$	0.49	308	283	0.92	0.0108	1.2	0.0469	9.8	69.4	±0.6
1-10.1$_c$	3.15	489	795	1.63	0.0109	2.1	0.0535	26.0	69.5	±1.1
1-11.1$_r$	1.19	151	76	0.50	0.0106	1.2	0.0437	5.7	68.5	±0.7
1-12.1$_r$	1.74	143	78	0.55	0.0107	1.8	0.0485	5.9	68.7	±1.0
1-13.1$_r$	0.63	477	269	0.56	0.0109	0.8	0.0517	4.5	69.8	±0.5
1-14.1$_r$	1.45	164	109	0.67	0.0107	1.8	0.0566	5.6	68.1	±1.0
1-15.1$_c$	2.10	256	224	0.88	0.0108	1.1	0.0489	12.4	68.8	±0.7

1-15.2$_{r}$	1.16	448	366	0.82	0.0104	1.0	0.0437	8.8	66.9	±0.5
1-16.1$_{r}$	3.21	125	78	0.63	0.0106	2.0	0.0373	10.0	69.0	±1.1
1-18.1$_{r}$	4.93	109	66	0.61	0.0107	2.9	0.0588	15.0	67.9	±1.8
1-19.1$_{r}$	7.27	105	58	0.56	0.0108	3.2	0.0525	17.9	69.1	±1.9
1-21.1$_{r}$	5.87	125	74	0.59	0.0106	3.0	0.0419	12.8	68.2	±1.5
1-22.1$_{r}$	1.75	135	74	0.55	0.0106	2.9	0.0500	5.6	68.0	±1.7
1-23.1$_{r}$	7.47	93	51	0.54	0.0108	3.5	0.0645	18.6	67.9	±1.8
2-1.1$_{c}$		335	223	0.66	0.0109	1.8	0.0445	6.4	69.9	±1.1
2-2.1$_{c}$	10.37	178	126	0.71	0.0111	1.7	0.0474	14.1	71.4	±0.9
2-3.2	0.07	143	108	0.75	0.0101	1.6	0.0449	12.2	65.0	±0.8
2-4.1$_{c}$		208	175	0.84	0.0106	3.0	0.0451	11.9	67.9	±1.7
2-4.2$_{r}$		178	93	0.52	0.0112	1.2	0.0527	5.5	71.6	±0.7
2-5.1$_{c}$		230	188	0.82	0.0108	3.2	0.0318	16.4	70.8	±1.9
2-6.1$_{c}$	0.51	352	386	1.09	0.0110	1.2	0.0609	11.5	69.3	±0.6
2-6.2$_{r}$		202	110	0.55	0.0103	1.3	0.0479	6.4	66.0	±0.7
2-7.1$_{c}$	0.43	617	569	0.92	0.0106	0.9	0.0470	8.0	67.7	±0.5
2-7.2$_{r}$		178	103	0.58	0.0108	1.3	0.0450	7.4	69.3	±0.8
2-8.1$_{c}$		203	185	0.91	0.0101	3.6	0.0420	15.6	65.3	±1.9
2-8.2$_{r}$	0.25	306	259	0.85	0.0109	2.2	0.0543	7.6	69.1	±1.3
Kwonyiri (315-4)										
1-20.2$_{r}$	13.78	148	135	0.91	0.0040	6.5	0.0467	84.0	25.7	±1.7
2-1.1$_{c}$	14.09	178	121	0.68	0.0042	8.1	0.0497	25.4	26.7	±1.6
2-1.2$_{r}$		162	105	0.65	0.0041	3.2	0.0403	15.5	26.4	±0.7
2-2.1$_{ic}$	0.47	245	241	0.99	0.0103	3.4	0.0472	15.3	66.0	±1.8
2-2.3$_{r}$	10.14	303	200	0.66	0.0042	1.7	0.0442	44.9	27.0	±0.7
2-3.1$_{ic}$	0.16	377	311	0.83	0.0103	1.1	0.0462	8.1	66.0	±0.6
2-3.2$_{ir}$	0.42	251	125	0.50	0.0100	2.5	0.0498	6.6	64.0	±1.3
2-3.4$_{r}$	0.62	247	195	0.79	0.0040	4.0	0.0321	23.2	26.2	±0.8
2-4.1$_{ic}$		5541	1035	0.19	0.0108	0.7	0.0492	1.7	69.2	±0.5
2-5.1$_{c}$		331	254	0.77	0.0044	3.2	0.0416	12.7	28.6	±0.8
2-5.2$_{r}$		299	251	0.84	0.0044	2.2	0.0520	13.4	28.2	±0.5
2-6.1$_{c}$	1.64	222	192	0.86	0.0043	1.7	0.0475	20.5	27.4	±0.3
2-6.2$_{r}$		401	430	1.07	0.0041	4.9	0.0321	35.9	27.1	±1.0
2-7.2$_{r}$	0.40	285	252	0.89	0.0044	5.4	0.0571	21.1	27.7	±1.2
2-8.1$_{c}$	0.83	382	307	0.81	0.0041	1.3	0.0447	17.5	26.5	±0.3
2-8.2$_{r}$	2.00	129	90	0.70	0.0040	5.8	0.0577	16.4	25.7	±1.3
Namsan (907-11)										
1-1.1$_{c}$	0.89	857	649	0.76	0.0085	1.1	0.0527	4.4	53.9	±0.5
1-1.2$_{r}$	26.26	1859	1075	0.58	0.0086	3.0	0.0463	47.2	55.4	±1.6
1-3.1$_{c}$	1.13	1649	1854	1.12	0.0086	1.1	0.0553	6.7	54.9	±0.5
1-3.2$_{r}$	0.36	1316	740	0.56	0.0087	1.0	0.0510	2.6	55.3	±0.5
1-7.1$_{c}$	15.62	788	569	0.72	0.0081	2.1	0.0449	16.5	52.2	±0.9

1-7.2$_r$	0.31	1691	986	0.58	0.0085	1.0	0.0480	2.5	54.4	±0.5
1-9.1$_c$	6.08	1579	1412	0.89	0.0084	1.4	0.0433	13.1	54.5	±0.5
1-9.2$_r$	1.57	3838	2976	0.78	0.0086	1.6	0.0482	3.0	55.2	±0.8
1-12.1$_c$	23.74	1385	1294	0.93	0.0086	4.5	0.0621	37.5	53.9	±1.6
1-12.2$_r$	10.80	2183	1897	0.87	0.0086	1.3	0.0493	6.5	55.1	±0.5
1-13.1$_c$	5.11	879	652	0.74	0.0083	2.4	0.0403	7.9	53.5	±1.0
1-13.2$_r$	5.81	636	374	0.59	0.0082	2.4	0.0515	6.3	52.1	±1.1
2-1.2$_r$		1385	851	0.61	0.0087	1.2	0.0505	2.5	55.4	±0.6
2-2.1$_c$		236	143	0.61	0.0083	3.2	0.0417	7.7	53.8	±1.5
2-3.1$_c$	0.23	1552	1280	0.82	0.0086	1.1	0.0510	5.2	55.0	±0.5
2-4.1$_c$	0.98	1381	882	0.64	0.0086	0.7	0.0593	2.8	54.1	±0.3
2-5.1	0.24	1838	1804	0.98	0.0086	1.1	0.0548	4.9	54.8	±0.5
2-6.1$_r$	0.11	2316	1807	0.78	0.0085	1.2	0.0495	5.3	54.1	±0.6
2-7.1	0.09	1842	1810	0.98	0.0085	0.8	0.0476	6.0	54.3	±0.3
2-8.1$_c$		34	24	0.70	0.0076	3.0	0.0345	33.3	49.4	±1.1
2-9.1	0.31	993	595	0.60	0.0085	1.2	0.0513	3.4	54.0	±0.6
Ijeonri (616-7)										
2-1.1		518	696	1.34	0.0138	2.4	0.0502	18.1	87.8	±1.6
2-1.2		368	452	1.23	0.0139	2.7	0.0535	15.5	88.3	±1.9
2-2.1$_c$	0.07	356	399	1.12	0.0134	1.2	0.0508	14.0	85.7	±0.7
2-2.2$_r$		116	69	0.59	0.0133	2.5	0.0472	8.1	85.4	±1.9
2-3.1$_c$		105	102	0.97	0.0134	3.5	0.0419	24.2	86.3	±2.5
2-3.2$_r$		83	57	0.68	0.0143	2.1	0.0402	16.5	92.6	±1.2
2-4.1$_c$	1.30	100	84	0.84	0.0138	2.5	0.0587	20.8	87.1	±1.2
2-4.2$_r$		906	1221	1.35	0.0139	0.9	0.0528	12.9	88.4	±0.6
2-5.1$_{ic}$		821	383	0.47	0.0414	0.7	0.0505	2.1	261.6	±1.7
2-6.1$_r$		597	317	0.53	0.0140	0.8	0.0451	3.3	89.7	±0.6
2-7.1$_c$		625	747	1.19	0.0141	1.7	0.0449	13.8	90.4	±1.2
2-8.1$_c$	0.58	105	62	0.59	0.0131	2.2	0.0374	11.6	84.7	±1.6
2-10.1$_c$	53.00	276	236	0.86	0.0140	8.1	0.0745	21.0	86.7	±2.8
Gigye (906-4)										
1-3.1$_{ic}$	0.22	1202	659	0.55	0.3612	1.5	0.1249	0.5	1981	±27
1-3.2$_{ir}$	1.15	757	140	0.19	0.3059	1.9	0.1097	0.5	1712	±31
1-8.2$_r$	5.44	114	90	0.79	0.0102	5.9	0.0143	91.0	68.2	±3.1
1-14.1$_c$	0.86	325	616	1.89	0.0105	3.2	0.0614	56.5	66.3	±1.4
1-14.2$_r$	3.63	277	465	1.68	0.0095	4.9	0.0631	43.7	60.0	±2.0
1-16.1$_r$	5.20	116	120	1.04	0.0109	2.6	0.0600	20.7	68.6	±1.3
2-1.1$_c$		1285	2822	2.20	0.0107	1.8	0.0576	43.7	67.5	±0.7
2-1.2$_r$	0.24	146	132	0.90	0.0100	4.6	0.0525	12.5	63.5	±2.4
2-2.1$_c$	0.26	154	240	1.56	0.0104	3.1	0.0575	45.3	65.7	±1.4
2-3.1$_c$	25.78	1179	3684	3.12	0.0104	7.5	0.0689	497.7	64.8	±1.8
2-4.1$_{ic}$		145	129	0.89	0.0321	1.2	0.0573	6.2	201.8	±2.0

2-5.1$_{c}$	0.48	207	420	2.03	0.0096	2.2	0.0368	158.8	62.6	±0.6
2-5.2$_{r}$		145	127	0.88	0.0109	1.5	0.0396	15.3	70.7	±0.8
2-6.1$_{c}$	0.24	328	690	2.10	0.0098	2.0	0.0288	180.0	64.2	±0.5
2-6.2$_{r}$		138	119	0.86	0.0106	1.5	0.0405	16.1	68.2	±0.8
2-7.1$_{c}$	0.51	160	269	1.69	0.0107	3.5	0.0695	46.6	66.6	±1.6
2-7.2$_{r}$		144	135	0.94	0.0100	2.0	0.0426	17.9	64.8	±1.0
Palgongsan (614-1)										
1-11.1$_{ic}$	0.15	572	448	0.78	0.0268	2.3	0.0543	2.7	169.3	±3.4
1-11.2$_{r}$	1.74	104	68	0.66	0.0104	3.0	0.0532	10.7	66.1	±1.6
1-14.1$_{c}$	0.62	312	371	1.19	0.0112	2.7	0.0561	11.5	71.0	±1.5
1-14.2$_{r}$	1.70	211	197	0.93	0.0107	2.8	0.0545	18.6	68.2	±1.7
2-1.1$_{c}$	0.48	102	73	0.71	0.0115	3.9	0.0559	7.9	72.7	±2.5
2-1.2$_{r}$	0.06	191	131	0.69	0.0112	1.1	0.0468	6.3	72.0	±0.7
2-2.1$_{r}$	0.09	217	144	0.67	0.0118	1.7	0.0474	5.7	75.8	±1.1
2-3.1$_{c}$	0.96	296	238	0.80	0.0124	0.9	0.0574	5.0	78.4	±0.6
2-3.2$_{r}$	1.75	171	89	0.52	0.0109	1.6	0.0577	5.0	69.3	±1.0
2-4.1$_{c}$	0.80	146	91	0.62	0.0110	1.3	0.0410	8.5	71.3	±0.7
2-5.1$_{c}$	0.63	171	188	1.10	0.0110	1.4	0.0565	15.3	69.4	±0.7
2-5.2$_{r}$		235	259	1.10	0.0119	2.7	0.0469	14.8	76.5	±1.7
2-6.1$_{c}$	0.13	303	307	1.01	0.0116	1.0	0.0559	8.6	73.5	±0.6
2-6.2$_{r}$	0.07	248	177	0.71	0.0112	2.4	0.0390	7.6	72.7	±1.5
2-7.1$_{c}$		238	192	0.81	0.0116	2.3	0.0518	13.1	74.2	±1.3
2-7.2$_{r}$		331	220	0.66	0.0113	0.9	0.0500	4.3	72.3	±0.5
2-8.1$_{c}$		180	121	0.67	0.0114	1.1	0.0530	5.3	72.7	±0.7
2-8.2$_{r}$	0.44	216	144	0.67	0.0115	1.4	0.0501	5.5	73.3	±0.9

[*] Analysis location: c, core; ic, inherited core; ir, inherited rim; r, rim

† All errors are percent, 1σ errors.

§ ^{207}Pb corrected ^{206}Pb/^{238} dates (< 1000 Ma) and ^{204}Pb corrected ^{207}Pb/^{206}Pb dates (> 1000 Ma). All errors are absolute, 1σ errors.

TABLE DR3. Summary of zircon oxygen and Lu-Yb-Hf isotopic composition

Spot number*	Date (Ma)*	$\delta^{18}O$ (‰)	2σ	$^{176}Hf/^{177}Hf$	2σ	$^{176}Lu/^{177}Hf$	2σ	$^{176}Yb/^{177}Hf$	2σ	εHf(t)	T_{DM} (Ma)	T_{2DM} (Ma)
Bangeojin (616-3)												
1-1.2$_c$				0.282888	0.000034	0.001706	0.000017	0.0565	0.0012	5.3	526	700
1-1.1$_r$	55.6			0.282928	0.000031	0.001646	0.000003	0.0508	0.0004	6.7	468	620
1-2.1$_r$	55.8			0.282943	0.000035	0.002734	0.000076	0.0831	0.0016	7.2	460	593
1-5.2$_c$				0.283027	0.000069	0.001888	0.000052	0.0589	0.0026	10.2	326	424
1-5.1$_r$	57.4			0.282967	0.000062	0.002128	0.000073	0.0603	0.0012	8.1	417	544
1-7.2$_c$				0.282941	0.000031	0.001646	0.000053	0.0504	0.0024	7.2	449	594
1-7.1$_r$	57.6			0.282967	0.000027	0.001056	0.000031	0.0327	0.0010	8.1	405	541
1-9.1$_{ic}$	66.3			0.282942	0.000030	0.001527	0.000033	0.0465	0.0013	7.4	446	589
1-9.2$_r$	57.8			0.282980	0.000033	0.001293	0.000015	0.0377	0.0005	8.6	389	516
1-12.1$_r$	57.7			0.283000	0.000053	0.002250	0.000083	0.0672	0.0014	9.3	370	478
1-13.1$_r$	56.2			0.282935	0.000046	0.002378	0.000094	0.0721	0.0018	7.0	467	608
1-14.1$_c$	60.4			0.282955	0.000033	0.001813	0.000056	0.0544	0.0025	7.7	431	567
1-14.2$_r$	56.4			0.282971	0.000029	0.001547	0.000011	0.0463	0.0005	8.3	404	534
1-15.2$_c$				0.282980	0.000037	0.001690	0.000080	0.0514	0.0027	8.6	393	517
1-15.1$_r$	55.0			0.282918	0.000040	0.001589	0.000056	0.0479	0.0013	6.4	481	640
2-1.1$_c$	57.6	5.23	0.25	0.282976	0.000033	0.001726	0.000093	0.0473	0.0027	8.4	399	525
2-1.2$_r$	58.3	5.25	0.16	0.282960	0.000025	0.001134	0.000016	0.0308	0.0007	7.9	416	555
2-2.1$_c$	57.4	4.90	0.21	0.282955	0.000040	0.002450	0.000130	0.0670	0.0033	7.7	438	568
2-2.2$_r$	61.2	4.85	0.19	0.282962	0.000026	0.003336	0.000068	0.0927	0.0029	7.9	439	556
2-2.3$_r$		4.94	0.19									
2-3.1$_c$	59.7	5.23	0.27	0.282957	0.000031	0.001690	0.000100	0.0451	0.0034	7.8	426	563
2-3.2$_r$	59.8	5.15	0.21	0.282947	0.000035	0.001960	0.000100	0.0556	0.0026	7.4	444	583
2-4.1$_c$	57.9	5.14	0.16	0.282977	0.000033	0.001462	0.000068	0.0379	0.0020	8.5	395	522
2-4.2$_r$	59.6	4.86	0.27	0.282946	0.000030	0.002592	0.000045	0.0716	0.0007	7.3	453	586
2-5.1$_c$	60.9	5.26	0.20	0.283143	0.000050	0.002830	0.000300	0.0880	0.0110	14.3	161	195
2-5.2$_r$	60.8	5.22	0.15	0.282952	0.000031	0.002200	0.000120	0.0574	0.0025	7.6	440	574
2-6.1$_c$	63.4	5.35	0.22	0.282994	0.000034	0.001650	0.000034	0.0439	0.0013	9.1	372	489
2-6.2$_r$	58.4	5.19	0.19	0.282961	0.000030	0.001702	0.000037	0.0460	0.0007	7.9	421	555
2-7.1$_c$	61.6			0.283028	0.000045	0.002008	0.000093	0.0537	0.0036	10.3	326	422
2-31.1$_c$		4.90	0.24	0.283006	0.000052	0.001237	0.000073	0.0327	0.0022	9.5	351	464
2-31.2$_r$		5.12	0.17	0.282976	0.000031	0.001257	0.000036	0.0331	0.0008	8.4	394	524
2-61.1$_c$				0.282980	0.000033	0.001390	0.000076	0.0402	0.0019	8.6	390	516
2-61.2$_r$				0.282965	0.000037	0.002400	0.000130	0.0679	0.0025	8.0	423	548
2-62.1$_c$				0.282999	0.000029	0.001780	0.000150	0.0509	0.0055	9.2	366	479
2-62.2$_r$				0.282952	0.000028	0.001097	0.000036	0.0285	0.0007	7.6	427	571
Daejeonri (316-3)												
1-3.1$_r$				0.282986	0.000068	0.002828	0.000071	0.0842	0.0046	8.5	396	511

1-6.2$_r$	48.1			0.282987	0.000037	0.001600	0.000006	0.0510	0.0005	8.6	382	507
1-8.1$_c$	47.9			0.282992	0.000042	0.001775	0.000051	0.0538	0.0009	8.8	376	497
1-15$_c$				0.282906	0.000050	0.001088	0.000016	0.0356	0.0011	5.8	492	667
1-16.1$_r$	46.9			0.282988	0.000054	0.001599	0.000039	0.0513	0.0007	8.6	380	505
2-1.1$_c$	46.5	4.94	0.19	0.283104	0.000073	0.001728	0.000023	0.0458	0.0004	12.7	213	274
2-1.2$_r$		4.43	0.13	0.283076	0.000055	0.001387	0.000024	0.0349	0.0005	11.8	251	329
2-2.1$_c$	42.2	4.68	0.23	0.283076	0.000065	0.001445	0.000059	0.0383	0.0020	11.8	252	329
2-2.2$_r$	46.7	4.47	0.16	0.283016	0.000046	0.001102	0.000010	0.0281	0.0009	9.6	335	448
2-3.1$_c$	49.4	4.78	0.13	0.283044	0.000036	0.001042	0.000014	0.0298	0.0009	10.6	295	392
2-3.2$_r$	47.8	4.84	0.16	0.283078	0.000040	0.001256	0.000017	0.0376	0.0002	11.8	248	325
2-4.2$_c$		4.84	0.16	0.283161	0.000055	0.001980	0.000130	0.0517	0.0045	14.7	131	161
2-4.1$_r$	46.8	4.48	0.13	0.283058	0.000066	0.001485	0.000038	0.0386	0.0010	11.1	278	365
2-5.1$_c$	48.8	4.68	0.19	0.283098	0.000045	0.001785	0.000026	0.0443	0.0009	12.5	222	286
2-5.2$_r$	43.9	4.64	0.23	0.283085	0.000061	0.001289	0.000032	0.0327	0.0012	12.1	238	311
2-6.1$_{ic}$	75.2	5.41	0.14	0.283052	0.000094	0.001810	0.000240	0.0450	0.0059	11.5	289	368
2-6.2$_r$	44.0	5.40	0.16	0.283149	0.000098	0.001750	0.000110	0.0422	0.0021	14.3	148	184
2-7.1$_c$	47.8	5.00	0.19	0.283075	0.000091	0.001689	0.000049	0.0432	0.0014	11.7	255	332
2-7.2$_r$	51.1	4.74	0.20	0.283119	0.000073	0.001252	0.000049	0.0317	0.0017	13.3	189	243
2-8.1$_c$	44.3	4.66	0.17	0.283032	0.000047	0.001610	0.000120	0.0389	0.0027	10.2	317	417
2-8.2$_r$		4.64	0.13	0.283062	0.000058	0.001624	0.000043	0.0394	0.0005	11.3	273	358
2-61.1$_c$				0.283213	0.000089	0.001706	0.000075	0.0405	0.0008	16.6	54	56
2-61.2$_r$				0.283049	0.000063	0.002049	0.000057	0.0523	0.0013	10.8	296	384
2-62.1$_c$				0.283017	0.000069	0.001519	0.000099	0.0366	0.0018	9.7	338	447
2-63.1$_r$				0.283113	0.000067	0.001577	0.000041	0.0377	0.0010	13.1	199	256
2-64.1$_c$				0.283031	0.000036	0.001551	0.000048	0.0411	0.0017	10.2	318	419
2-64.2$_r$				0.282977	0.000052	0.001729	0.000005	0.0446	0.0014	8.2	398	527
2-65.1$_c$				0.283008	0.000036	0.001694	0.000069	0.0449	0.0017	9.3	352	465
2-66.1$_r$				0.282985	0.000035	0.001646	0.000037	0.0452	0.0004	8.5	385	511
Seosaeng (317-1)												
1-4.2$_r$	67.9			0.282909	0.000037	0.000907	0.000018	0.0285	0.0004	6.3	485	652
1-5.2$_r$				0.282902	0.000024	0.000848	0.000013	0.0264	0.0003	6.1	495	666
1-6.2$_r$				0.282880	0.000022	0.000821	0.000027	0.0261	0.0008	5.3	525	709
1-14.1$_r$	68.1			0.282887	0.000022	0.000746	0.000015	0.0235	0.0004	5.5	514	695
1-15.1$_c$	68.8			0.282884	0.000023	0.000841	0.000007	0.0268	0.0002	5.4	520	702
1-16.1$_r$	69.0			0.282929	0.000037	0.000955	0.000027	0.0270	0.0005	7.0	458	613
1-19.1$_r$	69.1			0.282876	0.000037	0.000731	0.000026	0.0235	0.0008	5.1	530	717
1-23.1$_r$	67.9			0.282922	0.000026	0.000671	0.000003	0.0192	0.0002	6.8	464	626
2-1.2$_r$		5.72	0.23									
2-2.2$_r$		5.42	0.15									
2-3.1				0.282931	0.000038	0.001206	0.000020	0.0335	0.0007	7.1	458	609
2-3.2	65.0	5.73	0.18	0.282906	0.000031	0.001459	0.000055	0.0408	0.0019	6.2	497	659
2-4.1$_c$	67.9	5.80	0.19	0.282964	0.000037	0.001321	0.000024	0.0362	0.0004	8.2	412	544

2-4.3$_{c}$		5.94	0.19									
2-4.2$_{r}$	71.6	5.96	0.19	0.282959	0.000030	0.000985	0.000066	0.0256	0.0014	8.1	415	553
2-5.1$_{c}$	70.8	5.88	0.30	0.282991	0.000036	0.001128	0.000044	0.0308	0.0016	9.2	371	490
2-5.2$_{r}$		5.79	0.23	0.282979	0.000041	0.000935	0.000045	0.0230	0.0016	8.8	386	513
2-6.1$_{c}$	69.3	5.75	0.17	0.282950	0.000026	0.001061	0.000026	0.0280	0.0011	7.8	429	571
2-6.2$_{r}$	66.0	5.82	0.23	0.282933	0.000029	0.000807	0.000015	0.0209	0.0002	7.2	450	604
2-7.1$_{c}$	67.7	5.73	0.19	0.282988	0.000043	0.001346	0.000082	0.0349	0.0025	9.1	378	496
2-7.2$_{r}$	69.3	5.90	0.20	0.282913	0.000041	0.000932	0.000097	0.0209	0.0014	6.4	480	644
2-8.1$_{c}$	65.3	6.00	0.19	0.282965	0.000026	0.001494	0.000041	0.0400	0.0007	8.3	412	542
2-8.2$_{r}$	69.1	5.83	0.20	0.282945	0.000021	0.000665	0.000014	0.0163	0.0006	7.6	432	580
2-61.1$_{c}$				0.282928	0.000025	0.000754	0.000007	0.0200	0.0004	7.0	457	614
2-61.2$_{r}$				0.282932	0.000028	0.000667	0.000012	0.0166	0.0004	7.1	450	606
2-62.1$_{c}$				0.282954	0.000024	0.001249	0.000035	0.0333	0.0012	7.9	426	564
2-62.2$_{r}$				0.282939	0.000023	0.000889	0.000022	0.0232	0.0004	7.4	443	593
Kwonyiri (315-4)												
1-20.1$_{c}$				0.283141	0.000023	0.001692	0.000003	0.0626	0.0002	13.6	159	208
1-20.2$_{r}$	25.7			0.282967	0.000019	0.001605	0.000007	0.0470	0.0001	7.5	410	553
2-1.1$_{c}$	26.7	4.59	0.25	0.283036	0.000025	0.001403	0.000048	0.0355	0.0010	9.9	309	417
2-1.3$_{r}$		4.65	0.18									
2-1.2$_{r}$	26.4	4.63	0.17	0.283041	0.000036	0.001733	0.000054	0.0407	0.0007	10.1	305	407
2-2.1$_{ic}$	66.0	3.42	0.20	0.283128	0.000081	0.001837	0.000073	0.0464	0.0015	14.0	179	220
2-2.2$_{ic}$		3.30	0.18									
2-2.3$_{r}$	27.0			0.283059	0.000069	0.001940	0.000120	0.0433	0.0018	10.7	280	372
2-3.1$_{ic}$	66.0	4.40	0.24	0.282965	0.000057	0.001529	0.000063	0.0376	0.0011	8.2	413	543
2-3.2$_{ir}$	64.0	-0.06	0.15	0.282939	0.000067	0.001297	0.000078	0.0310	0.0010	7.3	448	595
2-3.3$_{ir}$		-0.70	0.18	0.282999	0.000055	0.001390	0.000099	0.0341	0.0017	9.4	362	476
2-3.4$_{r}$	26.2	4.57	0.17	0.283205	0.000072	0.001381	0.000067	0.0305	0.0009	15.9	65	80
2-4.1$_{ic}$	69.2	4.21	0.16	0.283142	0.000048	0.002030	0.000140	0.0517	0.0042	14.4	159	193
2-4.2$_{r}$		4.42	0.16									
2-5.1$_{c}$	28.6	4.40	0.21	0.282973	0.000043	0.001683	0.000073	0.0393	0.0015	7.7	403	542
2-5.2$_{r}$	28.2	4.75	0.13	0.283079	0.000053	0.001664	0.000053	0.0375	0.0006	11.4	249	331
2-6.1$_{c}$	27.4	4.61	0.22	0.283175	0.000079	0.002694	0.000047	0.0629	0.0006	14.8	113	141
2-6.2$_{r}$	27.1	4.74	0.20	0.283141	0.000080	0.001802	0.000072	0.0412	0.0008	13.6	159	208
2-7.1$_{ic}$		4.84	0.24	0.282995	0.000086	0.001359	0.000081	0.0333	0.0020		368	
2-7.2$_{r}$	27.7	4.75	0.14									
2-8.1$_{c}$	26.5	4.44	0.14	0.283138	0.000064	0.002290	0.000210	0.0569	0.0061	13.5	166	214
2-8.2$_{r}$	25.7	4.46	0.19									
2-61.1$_{c}$				0.283059	0.000035	0.001720	0.000100	0.0426	0.0033	10.7	278	371
2-61.2$_{r}$				0.283060	0.000027	0.002583	0.000032	0.0653	0.0010	10.7	284	370
2-62.1$_{c}$				0.283064	0.000035	0.001670	0.000130	0.0423	0.0045	10.9	271	361
2-62.2$_{r}$				0.283037	0.000031	0.001750	0.000110	0.0424	0.0040	9.9	311	415
2-63.1$_{c}$				0.283035	0.000039	0.002240	0.000110	0.0573	0.0037	9.9	318	420

2-63.2$_r$				0.283026	0.000034	0.001945	0.000033	0.0465	0.0012	9.5	328	437
Namsan (907-11)												
1-1.1$_c$	53.9			0.283303	0.000039	0.006965	0.000131	0.3657	0.0077	19.7	--	--
1-1.2$_r$	55.4			0.283023	0.000039	0.007164	0.000029	0.2850	0.0025	9.8	389	444
1-3.1$_c$	54.9			0.283087	0.000029	0.004045	0.000030	0.1676	0.0007	12.2	253	309
1-3.2$_r$	55.3			0.282992	0.000026	0.004224	0.000012	0.1973	0.0008	8.8	403	499
1-7.1$_c$	52.2			0.283269	0.000037	0.005540	0.000040	0.2416	0.0017	18.6	--	--
1-7.2$_r$	54.4			0.283105	0.000029	0.006234	0.000025	0.2438	0.0020	12.8	241	278
1-9.1$_c$	54.5			0.283039	0.000028	0.005057	0.000013	0.2304	0.0006	10.4	339	408
1-9.2$_r$	55.2			0.283180	0.000029	0.009001	0.000051	0.4285	0.0018	15.3	128	135
1-12.1$_c$	53.9			0.283078	0.000029	0.006875	0.000043	0.3235	0.0029	11.8	292	334
1-12.2$_r$	55.1			0.283250	0.000029	0.006615	0.000028	0.2473	0.0019	17.9	--	--
1-13.1$_c$	53.5			0.282960	0.000024	0.005033	0.000024	0.2264	0.0007	7.7	463	564
1-13.2$_r$	52.1			0.283055	0.000021	0.004476	0.000026	0.1719	0.0012	11.0	307	375
2-1.1$_c$		4.69	0.19	0.282988	0.000043	0.002270	0.000190	0.0658	0.0052	8.8	387	504
2-1.2$_r$	55.4			0.283050	0.000039	0.002710	0.000190	0.0820	0.0075	10.9	300	381
2-1.3$_r$		4.42	0.21	0.282994	0.000046	0.004218	0.000036	0.1304	0.0024	8.9	400	496
2-2.1$_c$	53.8	4.56	0.29	0.283097	0.000044	0.002908	0.000078	0.0851	0.0046	12.6	231	288
2-2.2$_r$		4.58	0.17									
2-2.3$_r$		4.88	0.17									
2-3.1$_c$	55.0	4.53	0.17	0.282981	0.000068	0.005360	0.000200	0.1686	0.0082	8.4	435	524
2-3.2$_c$		4.51	0.20									
2-3.3$_r$		4.21	0.21									
2-3.4$_r$		4.48	0.14	0.283047	0.000060	0.003781	0.000079	0.1166	0.0040	10.8	313	389
2-4.1$_c$	54.1	4.53	0.21	0.283109	0.000060	0.005058	0.000053	0.1583	0.0024	12.9	226	268
2-5.1	54.8	4.42	0.18	0.283082	0.000059	0.005112	0.000070	0.1657	0.0020	12.0	270	322
2-5.2		4.41	0.21	0.283104	0.000046	0.003540	0.000240	0.1108	0.0093	12.8	224	275
2-6.2$_c$		4.70	0.17	0.283075	0.000049	0.003575	0.000081	0.1041	0.0042	11.8	269	333
2-6.1$_r$	54.1	4.37	0.20	0.283017	0.000036	0.003960	0.000100	0.1235	0.0016	9.7	362	449
2-7.2		4.59	0.29	0.283085	0.000070	0.006960	0.000100	0.2222	0.0019	12.0	281	320
2-7.1	54.3	4.51	0.18	0.283041	0.000062	0.005413	0.000017	0.1781	0.0020	10.5	339	404
2-8.1$_c$	49.4	5.21	0.13	0.283047	0.000056	0.002740	0.000030	0.0866	0.0014	10.8	304	387
2-8.2$_c$		5.34	0.14									
2-8.3$_r$		4.72	0.19	0.282959	0.000074	0.002260	0.000170	0.0656	0.0049	7.7	430	561
2-8.4$_r$				0.283067	0.000051	0.003546	0.000058	0.1093	0.0026	11.5	281	349
2-9.1	54.0	4.61	0.21	0.283087	0.000069	0.002778	0.000076	0.0857	0.0038	12.2	245	308
2-31.1$_r$		4.74	0.14									
2-32.1		4.92	0.11	0.283034	0.000067	0.005090	0.000200	0.1570	0.0100	10.3	347	418
2-32.2		4.92	0.18	0.283013	0.000084	0.005020	0.000160	0.1570	0.0100	9.5	379	459
2-33.1$_c$				0.283104	0.000057	0.005779	0.000061	0.1798	0.0046	12.7	239	280
2-33.2$_r$				0.283109	0.000047	0.003916	0.000026	0.1237	0.0016	13.0	219	266
2-34.1$_c$		4.66	0.19	0.283078	0.000082	0.002813	0.000038	0.0814	0.0017	11.9	259	326

2-61.1$_c$				0.283074	0.000088	0.003720	0.000120	0.1179	0.0026	11.7	271	335
2-61.2$_r$				0.282992	0.000088	0.005010	0.000190	0.1608	0.0069	8.8	413	501
2-62.1$_c$				0.283206	0.000074	0.004399	0.000096	0.1374	0.0053	16.4	69	73
2-62.2$_r$				0.283210	0.000150	0.004370	0.000230	0.1344	0.0047	16.5	63	65
Ijeonri (616-7)												
2-1.1	87.8	5.15	0.18	0.282991	0.000032	0.002153	0.000080	0.0613	0.0024	9.6	382	486
2-1.3				0.283005	0.000036	0.001897	0.000063	0.0501	0.0027	10.1	359	457
2-1.2	88.3	5.10	0.17	0.283004	0.000046	0.001609	0.000062	0.0438	0.0020	10.0	357	458
2-2.1$_c$	85.7	5.11	0.19	0.282986	0.000026	0.000958	0.000048	0.0263	0.0017	9.4	377	492
2-2.2$_r$	85.4	5.05	0.23	0.282937	0.000021	0.000539	0.000005	0.0140	0.0002	7.7	441	588
2-3.1$_c$	86.3	4.97	0.18	0.282972	0.000027	0.001233	0.000025	0.0338	0.0004	8.9	400	520
2-3.2$_r$	92.6	5.02	0.18	0.282971	0.000023	0.000609	0.000005	0.0163	0.0004	8.9	394	520
2-4.1$_c$	87.1	5.07	0.21	0.282979	0.000041	0.000832	0.000083	0.0222	0.0025	9.2	385	505
2-4.2$_r$	88.4	4.71	0.20	0.283029	0.000047	0.000721	0.000060	0.0185	0.0019	11.0	314	405
2-4.3$_r$		4.57	0.29	0.282960	0.000035	0.001241	0.000051	0.0331	0.0015	8.5	417	544
2-5.1$_{ic}$	261.6	7.71	0.21	0.282490	0.000049	0.000810	0.000014	0.0206	0.0004	-4.4	1073	1401
2-5.2$_r$		5.04	0.17	0.282939	0.000042	0.001004	0.000033	0.0248	0.0005	7.8	444	585
2-6.3$_c$		4.82	0.23	0.282961	0.000038	0.000854	0.000033	0.0222	0.0007	8.6	411	541
2-6.1$_r$	89.7	4.59	0.22	0.282995	0.000033	0.001100	0.000069	0.0269	0.0012	9.8	365	474
2-6.2$_r$		4.61	0.22	0.283037	0.000031	0.000801	0.000037	0.0205	0.0008	11.3	303	390
2-7.1$_c$	90.4			0.283023	0.000049	0.001164	0.000097	0.0326	0.0032	10.7	326	419
2-7.2$_r$		4.77	0.20									
2-7.3$_r$		4.48	0.27	0.282974	0.000050	0.001161	0.000028	0.0300	0.0001	9.0	396	516
2-8.1$_c$	84.7	5.36	0.22	0.282971	0.000041	0.000979	0.000028	0.0251	0.0007	8.9	398	521
2-8.2$_r$		4.39	0.21	0.283026	0.000038	0.000824	0.000009	0.0209	0.0002	10.9	319	412
2-10.1$_c$	86.7			0.282992	0.000029	0.002130	0.000160	0.0622	0.0056	9.6	380	483
2-61.1$_c$				0.282981	0.000044	0.000672	0.000038	0.0179	0.0011	9.3	381	501
2-61.2$_r$				0.282992	0.000033	0.000607	0.000005	0.0154	0.0002	9.7	365	478
2-62.1				0.283035	0.000047	0.001808	0.000057	0.0481	0.0018	11.1	314	397
2-62.2				0.283022	0.000035	0.000904	0.000030	0.0216	0.0006	10.7	325	420
Gigye (906-4)												
1-3.1$_{ic}$	1981.4			0.281605	0.000020	0.001557	0.000013	0.0738	0.0007	0.9	2342	2478
1-8.1$_c$				0.282991	0.000039	0.006015	0.000043	0.2808	0.0024	8.9	427	503
1-8.2$_r$	68.2			0.282828	0.000029	0.002307	0.000009	0.0902	0.0006	3.3	624	818
1-14.1$_c$	66.3			0.282987	0.000032	0.007633	0.000032	0.3395	0.0016	8.7	457	515
1-14.2$_r$	60.0			0.282744	0.000023	0.002826	0.000032	0.1279	0.0018	0.3	757	984
1-16.2$_c$				0.282923	0.000029	0.005192	0.000045	0.2340	0.0026	6.6	525	635
1-16.1$_r$	68.6			0.282779	0.000020	0.002082	0.000029	0.0826	0.0004	1.6	690	912
2-1.1$_c$	67.5	5.77	0.19	0.283050	0.000110	0.005680	0.000430	0.1760	0.0140	11.0	327	385
2-1.2$_r$	63.5	5.82	0.15	0.282868	0.000069	0.001159	0.000087	0.0322	0.0036	4.8	547	735
2-2.1$_c$	65.7	6.19	0.16	0.283010	0.000120	0.002670	0.000130	0.0701	0.0050	9.7	359	457

2-2.2$_{r}$		6.33	0.18									
2-3.1$_{c}$	64.8	6.54	0.24	0.283013	0.000088	0.005190	0.000550	0.1580	0.0200	9.7	381	457
2-3.2$_{r}$		5.96	0.19									
2-4.1$_{ic}$	201.8	5.36	0.27	0.282840	0.000050	0.001700	0.000023	0.0484	0.0011	6.6	596	742
2-4.2$_{r}$		5.89	0.17	0.282926	0.000043	0.001154	0.000016	0.0309	0.0005	6.8	464	620
2-5.1$_{c}$	62.6	6.59	0.15	0.282910	0.000056	0.002010	0.000160	0.0540	0.0051	6.2	499	654
2-5.2$_{r}$	70.7	5.63	0.18	0.282978	0.000083	0.001007	0.000032	0.0273	0.0012	8.7	389	516
2-6.1$_{c}$	64.2	6.30	0.21	0.282860	0.000110	0.001828	0.000058	0.0537	0.0021	4.5	569	753
2-6.2$_{r}$	68.2	5.93	0.16	0.282894	0.000056	0.001147	0.000014	0.0315	0.0004	5.7	510	684
2-7.1$_{c}$	66.6	6.73	0.23	0.282878	0.000028	0.002230	0.000120	0.0608	0.0042	5.1	549	718
2-7.2$_{r}$	64.8	6.55	0.22	0.282852	0.000031	0.001409	0.000021	0.0384	0.0013	4.2	574	767
2-31.1$_{c}$		6.33	0.18	0.282853	0.000036	0.002577	0.000023	0.0693	0.0010	4.2	591	768
2-31.2$_{r}$		6.16	0.21	0.282903	0.000030	0.001536	0.000019	0.0423	0.0011	6.0	502	667
2-61.1$_{c}$				0.282876	0.000039	0.001940	0.000120	0.0535	0.0035	5.0	547	721
2-61.2$_{r}$				0.282858	0.000029	0.001221	0.000019	0.0333	0.0007	4.4	562	755
Palgongsan (614-1)												
1-11.1$_{ic}$	169.3			0.282502	0.000020	0.000860	0.000011	0.0300	0.0004	-5.9	1058	1414
1-11.2$_{r}$	66.1			0.282783	0.000018	0.001038	0.000002	0.0378	0.0002	1.9	666	900
1-14.1$_{c}$	71.0			0.282818	0.000027	0.002826	0.000089	0.1135	0.0049	3.1	648	837
1-14.2$_{r}$	68.2			0.282719	0.000019	0.001148	0.000002	0.0436	0.0002	-0.3	758	1027
1-18.1$_{c}$				0.282825	0.000019	0.001552	0.000003	0.0638	0.0003	3.4	615	819
1-18.2$_{r}$				0.282722	0.000015	0.001430	0.000026	0.0524	0.0003	-0.3	761	1022
1-20.1$_{c}$				0.282799	0.000016	0.001360	0.000008	0.0545	0.0004	2.5	648	869
1-20.2$_{r}$				0.282715	0.000016	0.000912	0.000004	0.0358	0.0002	-0.5	760	1034
2-1.1$_{c}$	72.7	5.61	0.26	0.282765	0.000046	0.001630	0.000078	0.0452	0.0025	1.3	703	938
2-1.2$_{r}$	72.0	5.44	0.23	0.282796	0.000030	0.001050	0.000007	0.0285	0.0003	2.4	648	875
2-2.2$_{c}$		5.83	0.24									
2-2.1$_{r}$	75.8	5.93	0.23									
2-3.1$_{c}$	78.4	5.68	0.20	0.282779	0.000036	0.002179	0.000089	0.0595	0.0035	1.7	693	911
2-3.2$_{r}$	69.3	5.99	0.26	0.282830	0.000048	0.001086	0.000045	0.0278	0.0015	3.6	600	808
2-4.1$_{c}$	71.3	5.53	0.21	0.282791	0.000083	0.001403	0.000027	0.0415	0.0003	2.2	661	886
2-4.2$_{r}$		5.85	0.19									
2-5.1$_{c}$	69.4	5.82	0.22	0.282588	0.000051	0.001850	0.000110	0.0506	0.0034	-5.0	962	1287
2-5.2$_{r}$	76.5	5.46	0.14	0.282610	0.000043	0.001990	0.000120	0.0548	0.0039	-4.2	934	1244
2-6.1$_{c}$	73.5	5.57	0.32	0.282761	0.000037	0.001840	0.000120	0.0508	0.0041	1.1	712	946
2-6.2$_{r}$	72.7	5.45	0.26	0.282752	0.000036	0.001224	0.000045	0.0314	0.0009	0.8	714	962
2-7.1$_{c}$	74.2	5.60	0.25	0.282739	0.000028	0.001780	0.000100	0.0475	0.0031	0.3	743	989
2-7.2$_{r}$	72.3	5.85	0.19	0.282754	0.000023	0.001052	0.000007	0.0270	0.0002	0.9	707	958
2-8.1$_{c}$	72.7	5.60	0.21	0.282771	0.000031	0.001725	0.000054	0.0466	0.0021	1.5	696	926
2-8.2$_{r}$	73.3	5.78	0.21	0.282762	0.000027	0.001406	0.000005	0.0372	0.0006	1.2	703	943
2-9.1$_{c}$				0.282811	0.000045	0.001300	0.000120	0.0355	0.0045	2.9	631	846
2-61.1$_{c}$				0.282752	0.000028	0.001492	0.000074	0.0398	0.0021	0.8	719	963

2-61.2r	0.282724	0.000027	0.001115	0.000008	0.0291	0.0002	-0.2	751	1017
2-62.1c	0.282741	0.000031	0.001668	0.000048	0.0456	0.0016	0.4	738	985
2-62.2r	0.282689	0.000033	0.001410	0.000059	0.0381	0.0011	-1.4	807	1087
2-63.1c	0.282727	0.000033	0.001384	0.000015	0.0371	0.0004	-0.1	752	1012
2-63.2r	0.282732	0.000042	0.001156	0.000024	0.0304	0.0004	0.1	741	1002

*Spot numbers and dates are taken from Table DR2.

TABLE DR4. Summary of Mg content and isotopic composition for biotite

Pluton name (Sample no.)	Mg (wt. %)	$\delta^{26}Mg$ (‰)	2σ	$\delta^{25}Mg$ (‰)	2σ	$\Delta\delta^{25}Mg'$	n
Biotite							
Bangeojin (616-3)	7.99	-0.23	0.06	-0.10	0.03	0.01	7
Daejeonri (316-3)	7.15	0.02	0.07	0.01	0.03	0.00	3
Seosaeng (317-1)	6.62	-0.20	0.01	-0.11	0.03	0.00	4
Kwonyiri (315-4)	8.49	-0.18	0.06	-0.09	0.02	0.01	3
Namsan (907-11)	0.34	2.32	0.05	1.18	0.01	-0.02	3
Ijeonri (616-7)	6.58	0.04	0.03	0.01	0.02	-0.01	3
Gigye (906-4)	8.79	-0.07	0.03	-0.03	0.03	0.01	4
Palgongsan (614-1)	6.22	-0.14	0.04	-0.05	0.03	0.02	8
Rock standards							
GSP-2	0.56	-0.02	0.02	-0.02	0.01	-0.01	7
MAG-1	1.86	-0.19	0.03	-0.09	0.06	0.01	7
BIR-1	N.D.*	-0.20	0.05	-0.12	0.09	-0.02	3
Reference materials							
DSM-3	N.D.	-0.01	0.06	0.00	0.05	0.00	408
CAM-1	N.D.	-2.62	0.06	-1.35	0.04	0.02	404
SRM 980	N.D.	-4.32	0.09	-2.22	0.05	0.03	249

*N.D. = not determined.

Figure DR1. Raman spectroscopic analyses of zircon crystals from the Kwonyiri, Ijeonri, Namsan, and Gigye samples. Spectra obtained from the 91500 and Penglai zircons are also shown for reference. All zircons show the distinctive zircon peaks (gray vertical lines).

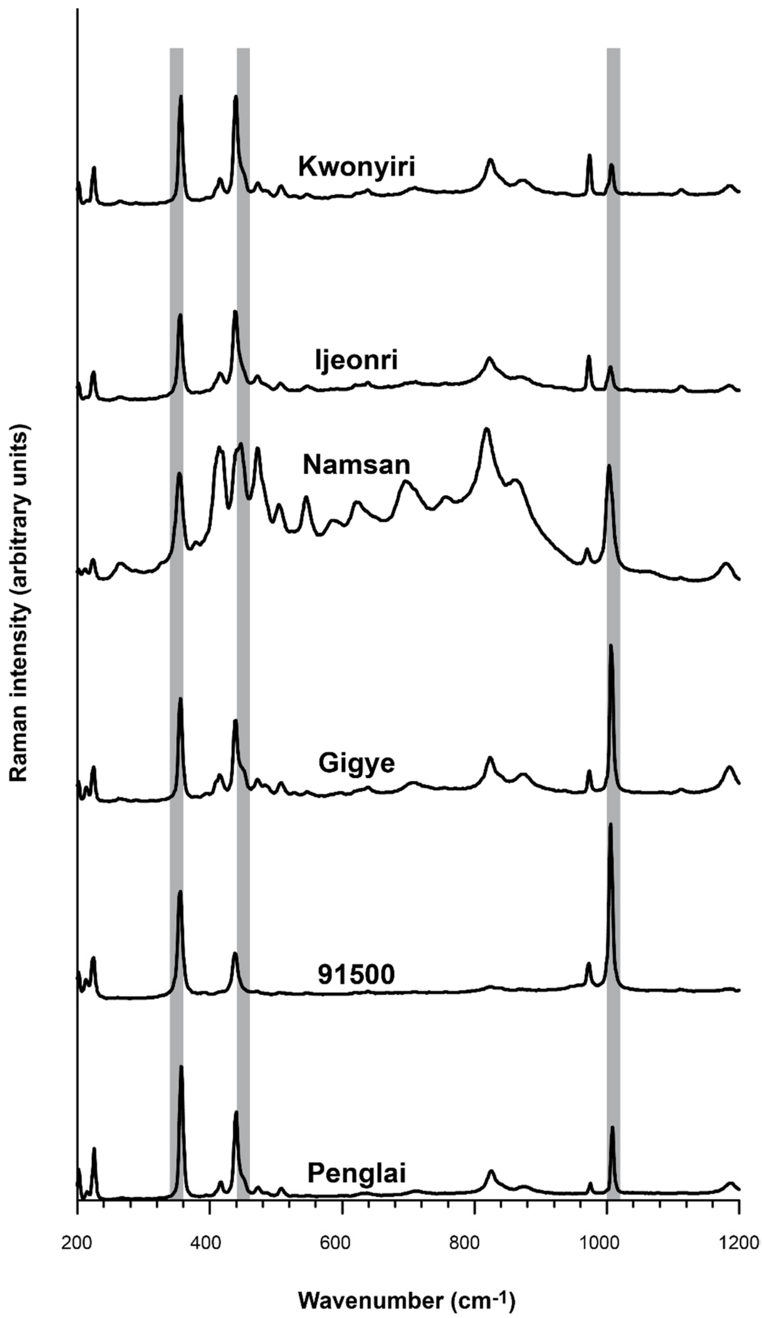
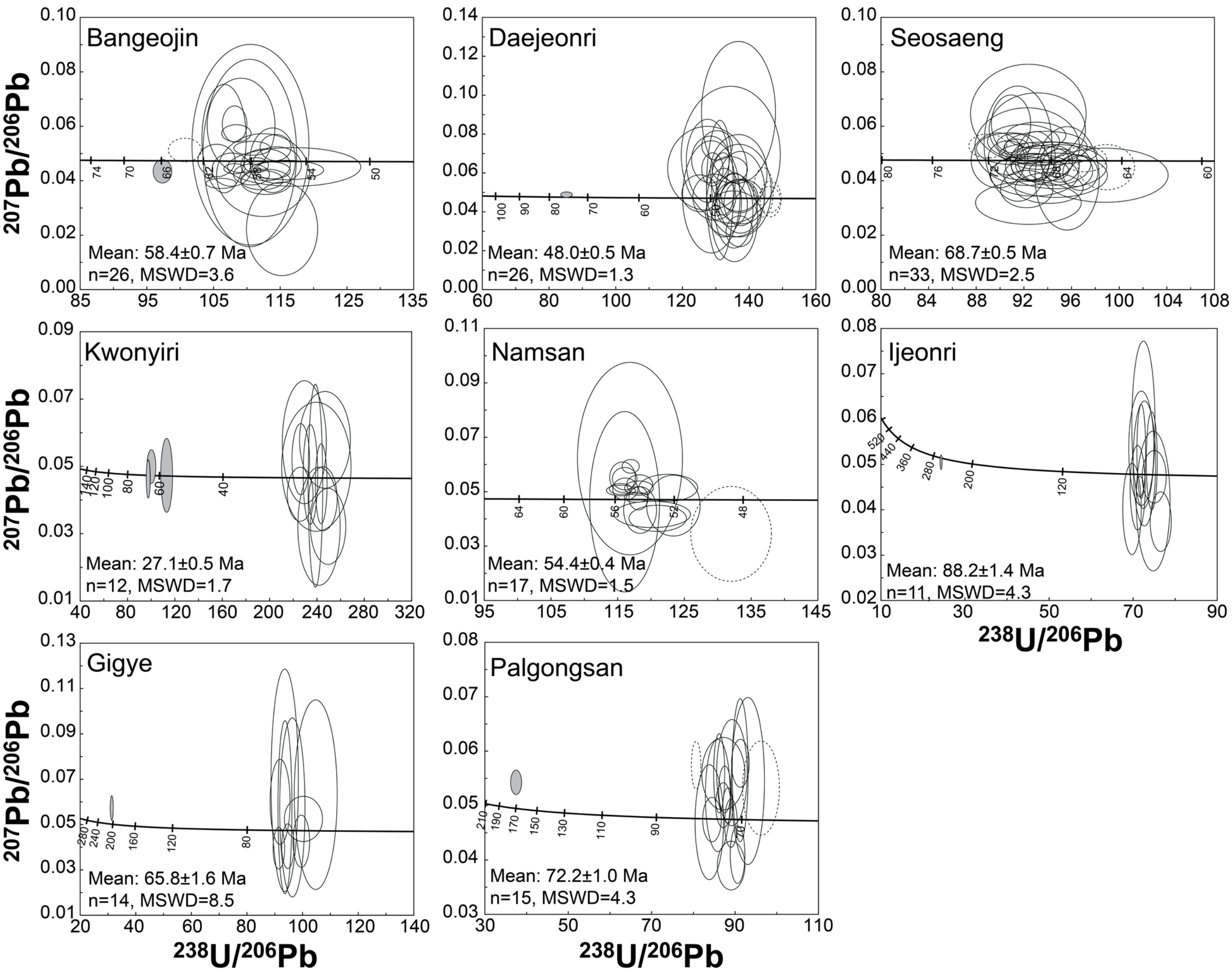


Figure DR2. Tera-Wasserburg concordia diagrams of SHRIMP zircon U-Pb data, with weighted mean $^{206}Pb/^{238}U$ ages and uncertainties at the 95% confidence level. Error ellipses are at the 1-sigma level. Gray ellipses represent the xenocrystic cores. Dotted ellipses are outliers determined by statistical t-tests in the calculation of weighted mean ages. Data points represent ^{208}Pb-corrected ratios. The Paleoproterozoic inherited zircon in the Gigye sample is not shown for clarity. It is noted that the name of sample 0316-3 from "Daejeonri" in Cheong et al. (2013) should be corrected to sample 0419-2, collected from "Tohamsan".



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