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Supplemental Figure S3: Scanning electron microscope cathodoluminescence images of zircon in samples (A) 1333E, (B) 13204, and (C) 13118A.

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Supplemental Figure S5: Results of depth profiling in zircon from sample 1204.

DETAILED DESCRIPTION OF METHODS

U-Pb zircon geochronology (summarized in Supplementary Table 1) was conducted by ion microprobe at the Stanford-USGS SHRIMP-RG facility (Supplementary Table 2) and by laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) at the Arizona LaserChron Center (Supplementary Table 3).

SHRIMP-RG Geochronology Methods

Ion microprobe data were collected during three sessions on the following days: 04/04/2012 to 04/07/2012, 05/13/2013 to 05/15/2013 and 7/7/2014 to 7/10/2014. Five mounts were used: 12CSUN1, 12CSUN3, 13CSUN15, 14CSUN37, 14CSUN38. Zircon grains were concentrated by standard heavy mineral separation processes, hand selected for final purity, mounted on double-sided tape on glass slides in ca. 1 x 6 mm rows, cast in a 25 mm diameter by 4 mm thick epoxy disc, ground, and polished to a 1 micron finish. All grains were imaged with transmitted light and reflected light on a petrographic microscope, and with cathodoluminescence to identify internal structure, inclusions and physical defects. The mounted grains were washed with a 1N HCl solution, rinsed in distilled water, and dried in a vacuum oven. The sample surface was coated with ~100Å Au and inspected to ensure uniformity and conductivity before loading into the pre-evacuation chamber of the instrument. The mounts were stored at high pressure (10^{-7} torr) for several hours before being moved into the source chamber of the SHRIMP-RG to minimize degassing of the epoxy and isobaric hydride interferences and masses 204-208.

During the analyses, secondary ions were sputtered from each target spot using an O_2^- primary ion beam, which was accelerated at 10 kV and had an intensity varying from 4.3 to 5.4 nA. The primary ion beam spot had a diameter between 22-28 microns and a depth of ~1-2 microns. Before every analysis, the sample surface was cleaned by rastering the primary beam for 60-120, and the primary and secondary beams were auto-tuned to maximize transmission. The duration of procedure typically required 2.5 minutes prior to data collection. The acquisition routine includes analysis of $^{30}Si^{16}O$, $^{48}Ti^+$, $^{49}Ti^+$, $^{56}Fe^+$, $^{89}Y^+$, $^{139}La^+$, $^{140}Ce^+$, $^{146}Nd^+$, $^{147}Sm^+$, $^{153}Eu^+$, $^{157}Gd^{16}O^+$, $^{163}Dy^{16}O^+$, $^{166}Er^{16}O^+$, $^{172}Yb^{16}O^+$), a high mass normalizing species ($^{40}Ca^{48}Ca^{48}Ti^{16}O_2^+$), followed by $^{180}Hf^{16}O^+$, $^{204}Pb^+$, a background measured at 0.045 mass units above the $^{204}Pb^+$ peak, $^{206}Pb^+$, $^{207}Pb^+$, $^{208}Pb^+$, $^{232}Th^+$, $^{238}U^+$, $^{232}Th^{16}O^+$, $^{238}U^{16}O^+$, and $^{238}U^{16}O_2^+$. Trace element measurements (Ti, Y, REE, Hf) were measured briefly (typically 1 to 3 sec/mass) immediately before the geochronology peaks, and in mass order. All peaks were measured on a single EPT® discrete-dynode electron multiplier operated in pulse counting mode. Mounts 12CSUN1 and 12CSUN3 did not include measurement of SiO, Ti, or Fe. Mounts number 12CSUN1 abd 12CSUN3 were analyzed with 5 scans (peak-hopping cycles from mass 46 through 270). Mount 13CSUN15 was analyzed with a shorter run table (Gd, YbO, Zr_2O, HfO, $^+$, ^{204}Pb, background, ^{206}Pb, ^{207}Pb, ^{208}Pb, U, ThO, and UO), a 7.8-8.2 nA O_2^- primary ion beam intensity, and longer count times for ^{206}Pb, ^{207}Pb, and ^{238}U, and 7 scans. The number of scans through the mass sequence and counting times on each peak are varied according to the sample age and the U and Th concentrations to improve counting statistics and age precision. Samples on 13CSUN15 contained low-U zircons, and therefore, require increased count times and number of cycles in order to maximize precision on the U/Pb measurement.

For mounts 12CSUN1 and 12CSUN3, zircon concentration data for U, Th and all of the measured trace elements are standardized against well-characterized, homogeneous zircon standards MAD-green (4196 ppm U, Barth and Wooden, 2010), which was mounted on a separate setup mount. Trace element concentrations for mounts 13CSUN15, 14CSUN37 and 14CSUN38 were calculated relative to MADDER (3435 ppm U)—a well-characterized, homogeneous in-house zircon standard that is calibrated relative to MAD-green, which was co-mounted with unknowns on each mount. Calculated model ages for zircon are standardized relative to R33 ($^{206}Pb/^{238}U$ age = 419 Ma; Black et al., 2004), which were analyzed repeatedly throughout the duration of the analytical session (every fifth analysis). Error-weighted average ages were calculated in Isoplot 3.00 (Ludwig, 2003).

LA-MC-ICPMS Geochronology Methods

LA-MC-ICPMS analyses involve ablation of zircon with a New Wave/Lambda Physik DUV193 Excimer laser (operating at a wavelength of 193 nm) using a spot diameter of 30 microns. The ablated material is carried with helium gas into the plasma source of a GV Instruments Isoprobe, which is equipped with a flight tube of sufficient width that U, Th, and Pb isotopes are measured simultaneously. All measurements are made in static mode, using Faraday detectors for ^{238}U and ^{232}Th, an ion-counting channel for ^{204}Pb, and either faraday collectors or ion counting channels for $^{208-206}Pb$. Ion yields are ~1 mv per ppm. Each analysis consists of one 12-second integration on peaks with the laser off (for backgrounds), 12 one-second integrations with the laser firing, and a 30 second delay to purge the previous sample and prepare for the next analysis. The ablation pit is ~12 microns in depth.

For each analysis, the errors in determining $^{238}U/^{206}Pb$ and $^{206}Pb/^{204}Pb$ result in a measurement error of ~1% (at 2σ level) in the $^{238}U/^{206}Pb$ age. The errors in measurement of $^{206}Pb/^{207}Pb$ and $^{206}Pb/^{204}Pb$ also result in ~1% (2σ) uncertainty in age for grains that are >1.0 Ga, but are substantially larger for younger grains due to low intensity of the ^{207}Pb signal. For most analyses, the cross-over in precision of $^{238}U/^{206}Pb$ and $^{206}Pb/^{207}Pb$ ages occurs at ~1.0 Ga.

Common Pb correction is accomplished by using the measured ^{204}Pb and assuming an initial Pb composition from Stacey and Kramers (1975) (with uncertainties of 1.0 for $^{206}Pb/^{204}Pb$ and 0.3 for $^{207}Pb/^{204}Pb$). Measurement of ^{204}Pb is unaffected by the presence of ^{204}Hg because backgrounds are measured on peaks (thereby subtracting any background ^{204}Hg and ^{204}Pb), and because very little Hg is present in the argon gas.

Inter-element fractionation of Pb/U is generally ~20%, whereas apparent fractionation of Pb isotopes is generally <2%. In-run analysis of fragments of a large zircon crystal (generally every fifth measurement) with known age of 564 ± 4 Ma (2σ error) is used to correct for this fractionation. The uncertainty resulting from the calibration correction is generally ~1% (2σ) for both $^{206}Pb/^{207}Pb$ and $^{238}U/^{206}Pb$ ages. The analytical data are reported in Table 4. Uncertainties shown in these tables are at the 1σ level, and include only measurement errors. The reported ages are determined from the weighted mean (Ludwig, 2003) of the $^{206}Pb/^{238}U$ ages of the concordant and overlapping analyses. Two uncertainties are reported on these plots. The smaller uncertainty (labeled "mean") is based on the scatter and precision of the set of $^{206}Pb/^{238}U$ ages, weighted according to their measurement errors (shown at 1σ). The larger uncertainty (labeled "age"), which is the reported uncertainty of the age, is determined as the quadratic sum of the weighted mean error plus the total systematic error for the set of analyses. The systematic error, which includes contributions from the standard calibration, age of the calibration standard, composition of common Pb, and U decay constants, is generally ~1-2% (2σ).

REFERENCES CITED

Barth, A. P., and Wooden, J.L., 2010, Coupled elemental and isotopic analyses of polygenetic zircons from granitic rocks by ion microprobe, with implications for melt evolution and the source of granitic magmas: Chemical Geology, v. 277, p. 149-159.

Black, L.P., Kamo, S.L., Allen, C.M., Davis, D.W., Aleinikoff, J.N., Valley, J.W., Mundil, R., Campbell, I.H., Korsch, R.J., Williams, I.S., and Foudoulis, C., 2004, Improved $^{206}Pb/^{238}U$ microprobe geochronology by the monitoring of a trace-element-related matrix effect; SHRIMP, ID–TIMS, ELA–ICP–MS and oxygen isotope documentation for a series of zircon standards: Chemical Geology, v. 205, p. 115-140.

Ludwig, K.R., 2003, Isoplot 3.00. Berkeley Geochronology Center, Special Publication 4, 70 p.

Stacey, J.S., and Kramers, J.D., 1975, Approximation of terrestrial lead isotope evolution by a two-stage model: Earth and Planetary Science Letters, v. 26, p. 207-221.

Turnbull, I.M., Allibone, A.H., and Jongens, R., 2010, Geology of the Fiordland area: Institute of Geological and Nuclear Sciences, Lower Hutt, New Zealand, scale 1:250 000, sheet 17, 97 p. text.

Supplementary Table 1: Sample locations for plutonic rocks in Fiordland, New Zealand

Sample	*Unit*	*Rock type*	*Latitude*	*Longitude*	*Significance*	*Temperatu re (°C) ±1 s*	*$^{206}Pb/^{238}U$ age (Ma) ±2 s*	*Xenocryst population $^{206}Pb/^{238}U$ age (Ma) ±2 s*
1254	Malaspina Pluton (WFO)	trondhjemite dike	45°22'28.96"S	167°04'43.97"E	post-kinematic	n.d.	97.8 ± 1.3	108.4 ± 2.9
1256	Malaspina Pluton (WFO)	trondhjemite dike	45°22'37.92"S	167°04'57.40"E	syn-kinematic	n.d.	101.4 ± 1.7	107.7 ± 4.5
1204	Deep Cove Gneiss	felsic orthogneiss	45°26'40.60"S	167°07'53.85"E	metam. zircon	n.d.	113.5 ± 1.7	372.0 ± 4.0
1241	Malaspina Pluton (WFO)	diorite orthogneiss	45°24'49.17"S	166°56'11.66"E	interm. magmatisr	n.d.	115.9 ± 1.2	none
1304b	Deep Cove Gneiss	garnet-bearing orthogneiss	45°22'41.15"S	167°03'00.64"E	metam. zircon	670 ± 24	117.2 ± 0.8 (rim	none
13204	Resolution Orthogneiss (WFO)	trondhjemite dike	45°36'17.69"S	166°39'48.03"E	syn-kinematic	n.d.	109.4 ± 2.5	ca. 118-120 Ma
13118A	Malaspina Pluton (WFO)	trondhjemite dike	45°33'43.01"S	166°47'13.82"E	felsic magmatism	n.d.	no Cret. Dates	ca. 550 and 1080 Ma
1333E	Breaksea Orthogneiss (WFO)	garnet granulite orthogneis	45°35'31.78"S	166°38'32.68"E	mafic magmatism	n.d.	123.2 ± 1.3	none
1333D	Breaksea Orthogneiss (WFO)	amphibolite	45°35'31.78"S	166°38'32.68"E	metam. zircon	619 ± 60	88.8 ± 4.7 (rim)	ca. 117-123 Ma
0649	Resolution Orthogneiss (WFO)	trondhjemite dike	45°36'03.06"S	166°40'51.85"E	post-kinematic	n.d.	89.3 ± 1.8	none

n.d. = not determined

Supplementary Table 2: U-Pb (zircon) SHRIMP isotopic analyses and ages.

	Concentrations					Atomic Ratios[i]						Age (Ma)		
Grain[ii]	U (ppm)	Th (ppm)	Th/U	Pb*[iii] (ppm)	*f* 206[iv] (%)	$^{238}U/^{206}Pb$[v]	% err (1σ)	$^{207}Pb/^{206}Pb$[v]	% err (1σ)	$^{206}Pb/^{238}U$[vi]	% err (1σ)	$^{206}Pb/^{238}U$[vii]	err abs (1σ)	Weighted Average age (2σ)
Post-kinematic dike (Malaspina Pluton)														
1254-1.1	65.06	0.90	0.01	0.84	0.02	66.63	2.09	0.0481	7.57	0.01501	2.14646	96.01	2.05	**Younger population:**
1254-10.1	1399.23	3.90	0.00	18.70	0.19	64.28	0.98	0.0495	1.72	0.01553	0.99042	99.32	0.98	**97.8 ± 1.3**
1254-16.1	3.74	0.02	0.01	0.05	-0.02	65.48	7.33	0.0478	29.73	0.01527	7.56589	97.72	7.34	**MSWD = 0.9**
1254-45.1	796.92	1.75	0.00	10.42	0.06	65.71	1.05	0.0485	2.38	0.01521	1.06330	97.31	1.03	**n = 7**
1254-In-2.1	3.41	0.02	0.00	0.05	5.58	64.66	8.81	0.0922	24.21	0.01460	9.32424	93.45	8.65	
1254-In-3.1	8.36	0.08	0.01	0.11	3.64	65.42	5.17	0.0768	22.52	0.01473	5.65746	94.26	5.29	
1254-In-4.1	2.59	0.01	0.01	0.03	15.92	64.01	9.73	0.1740	20.25	0.01314	11.0977	84.13	9.28	
1254-In-6.1	4.31	0.04	0.01	0.05	0.50	69.56	7.03	0.0518	30.05	0.01430	7.3198	91.56	6.65	
1254-In-8.1	2.80	0.04	0.02	0.04	4.79	68.11	8.78	0.0858	26.48	0.01398	9.29724	89.49	8.26	
1254-In-9.1	10.47	0.06	0.01	0.17	18.13	54.06	4.45	0.1919	11.46	0.01514	5.60792	96.89	5.39	
1254-In-11.1	*1.14*	*0.01*	*0.01*	*0.01*	*9.14*	*78.04*	*14.39*	*0.1200*	*40.75*	*0.01164*	*15.9405*	*74.62*	*11.83*	
Syn-kinematic dike (Malaspina Pluton)														
1256-4.1	102.34	2.21	0.02	1.39	-0.04	63.30	1.70	0.0477	6.43	0.01580	1.75234	101.08	1.76	**Younger population:**
1256-7.1	*22.83*	*0.24*	*0.01*	*0.28*	*-0.35*	*69.06*	*3.30*	*0.0451*	*14.33*	*0.01453*	*3.40904*	*92.99*	*3.15*	**101.4 ± 1.7**
1256-16.1	120.59	5.12	0.04	1.64	-0.17	63.36	1.59	0.0467	5.72	0.01581	1.62996	101.12	1.64	**MSWD = 0.9**
1256-17.1	136.27	5.00	0.04	1.88	-0.42	62.25	1.50	0.0448	5.39	0.01613	1.53022	103.16	1.57	
1256-18.1	69.61	2.07	0.03	0.96	-0.38	62.47	1.91	0.0450	7.60	0.01607	1.96039	102.76	2.00	
1256-33.1	26.36	0.41	0.02	0.39	12.14	57.92	4.93	0.1444	37.33	0.01517	9.18997	97.04	8.85	
1256-47.1	38.80	0.34	0.01	0.51	-0.99	65.78	2.49	0.0401	11.06	0.01535	2.55335	98.22	2.49	
1256-49.1	133.33	2.07	0.02	1.91	10.38	59.86	1.62	0.1303	24.60	0.01497	4.80124	95.81	4.57	
Deep Cove Gneiss														
1204-3.1	219.62	122.42	0.56	11.18	-0.13	16.88	1.10	0.0530	1.93	0.05933	1.12085	371.58	4.05	**Younger population:**
1204-3.2	*816.99*	*90.23*	*0.11*	*39.48*	*0.28*	*17.78*	*0.95*	*0.0558*	*1.22*	*0.05609*	*0.95911*	*351.81*	*3.28*	**113.5 ± 1.7**
1204-5.1	231.26	173.88	0.75	11.98	-0.09	16.59	1.05	0.0534	1.88	0.06033	1.07177	377.66	3.93	**MSWD = 0.03**
1204-5.2	*1050.47*	*64.96*	*0.06*	*20.26*	*3.06*	*44.55*	*0.98*	*0.0732*	*2.16*	*0.02176*	*1.00572*	*138.78*	*1.38*	**n = 2**
1204-6.1	*1415.93*	*332.75*	*0.24*	*61.44*	*0.14*	*19.80*	*0.93*	*0.0539*	*0.97*	*0.05044*	*0.94019*	*317.20*	*2.91*	
1204-7.1	532.98	286.74	0.54	27.03	0.00	16.94	0.97	0.0540	1.67	0.05903	0.98351	369.72	3.53	**Older population:**
1204-11.1	*1497.62*	*221.08*	*0.15*	*68.55*	*0.09*	*18.77*	*0.92*	*0.0538*	*0.79*	*0.05323*	*0.93446*	*334.35*	*3.04*	**372.0 ± 4.0**
1204-11.2	313.33	153.21	0.49	16.06	0.06	16.76	1.02	0.0546	1.64	0.05961	1.03289	373.26	3.75	**MSWD = 1.8**
1204-12.1	*890.58*	*139.87*	*0.16*	*36.21*	*0.13*	*21.13*	*0.94*	*0.0533*	*1.08*	*0.04727*	*0.95559*	*297.71*	*2.78*	**n = 9**
1204-14.1	840.82	108.28	0.13	43.39	0.41	16.65	0.96	0.0574	1.05	0.05981	0.97550	374.49	3.55	
1204-16.1	*832.71*	*101.35*	*0.12*	*31.31*	*0.10*	*22.85*	*0.96*	*0.0526*	*1.24*	*0.04372*	*0.9705*	*275.82*	*2.62*	
1204-17.1	*1253.87*	*135.81*	*0.11*	*47.30*	*0.17*	*22.77*	*0.95*	*0.0532*	*1.14*	*0.04384*	*0.95989*	*276.56*	*2.60*	
1204-17.2	*223.29*	*105.11*	*0.47*	*12.06*	*-0.04*	*15.91*	*1.12*	*0.0542*	*1.98*	*0.06287*	*1.14253*	*393.05*	*4.36*	
1204-21.1	1340.83	173.94	0.13	69.76	-0.01	16.51	0.93	0.0541	0.78	0.06057	0.94574	379.10	3.48	
1204-36.1	*1357.14*	*57.73*	*0.04*	*27.42*	*0.26*	*42.51*	*0.96*	*0.0511*	*1.41*	*0.02346*	*0.97054*	*149.49*	*1.43*	
1204-38.1	511.02	211.19	0.41	25.78	-0.10	17.03	0.97	0.0531	1.26	0.05879	0.98131	368.24	3.51	
1204-53.1	*278.18*	*168.73*	*0.61*	*13.62*	*0.18*	*17.55*	*1.07*	*0.0551*	*3.17*	*0.05689*	*1.10295*	*356.69*	*3.83*	
1204-55.1	*1257.62*	*105.40*	*0.08*	*20.41*	*0.08*	*52.95*	*0.97*	*0.0491*	*1.56*	*0.01887*	*0.97715*	*120.52*	*1.17*	
1204-59.1	276.50	119.54	0.43	13.83	0.07	17.18	1.07	0.0544	1.80	0.05817	1.08471	364.46	3.84	

Supplementary Table 2: U-Pb (zircon) SHRIMP isotopic analyses and ages.

	Concentrations					Atomic Ratios[i]						Age (Ma)		
Grain[ii]	U (ppm)	Th (ppm)	Th/U	Pb*[iii] (ppm)	*f* 206[iv] (%)	^{238}U/^{206}Pb[v]	% err (1□)	^{207}Pb/^{206}Pb[v]	% err (1□)	^{206}Pb/^{238}U[vi]	% err (1□)	^{206}Pb/^{238}U[vii]	err abs (1□)	Weighted Average age (2□)
1204-59.2	*1284.13*	*36.06*	*0.03*	*23.26*	*0.64*	*47.43*	*0.97*	*0.0538*	*1.53*	*0.02095*	*0.98365*	*133.65*	*1.30*	
1204-69.1	*477.83*	*42.60*	*0.09*	*7.34*	*0.60*	*55.90*	*1.10*	*0.0531*	*3.59*	*0.01778*	*1.12519*	*113.62*	*1.27*	
1204-72.1	*2963.09*	*293.61*	*0.10*	*177.18*	*-0.11*	*14.37*	*0.91*	*0.0547*	*0.48*	*0.06968*	*0.92672*	*434.21*	*3.89*	
1204-72.2	*346.76*	*152.10*	*0.44*	*15.13*	*0.23*	*19.69*	*1.02*	*0.0546*	*1.72*	*0.05068*	*1.03484*	*318.69*	*3.22*	
1204-In-1.1	*1135.01*	*155.23*	*0.14*	*52.14*	*0.13*	*18.70*	*0.94*	*0.0542*	*1.38*	*0.05340*	*0.95217*	*335.37*	*3.11*	
1204-In-2.1	*1117.27*	*273.18*	*0.24*	*48.28*	*-0.08*	*19.88*	*0.97*	*0.0521*	*1.61*	*0.05034*	*0.98212*	*316.61*	*3.03*	
1204-In-3.1	*1310.11*	*117.16*	*0.09*	*20.70*	*0.05*	*54.38*	*1.04*	*0.0488*	*3.10*	*0.01838*	*1.06267*	*117.41*	*1.24*	
1204-In-5.1	*891.23*	*31.16*	*0.03*	*41.35*	*0.05*	*18.51*	*0.99*	*0.0537*	*1.64*	*0.05398*	*1.00509*	*338.93*	*3.32*	
1204-In-6.1	*1001.43*	*30.27*	*0.03*	*16.12*	*0.30*	*53.37*	*1.09*	*0.0508*	*2.54*	*0.01868*	*1.10262*	*119.32*	*1.30*	
1204-In-7.1	*1279.11*	*85.27*	*0.07*	*24.16*	*0.21*	*45.48*	*1.15*	*0.0505*	*5.23*	*0.02194*	*1.20162*	*139.92*	*1.66*	
1204-In-8.1	*1437.31*	*194.08*	*0.14*	*68.33*	*0.07*	*18.07*	*0.93*	*0.0540*	*1.27*	*0.05530*	*0.93864*	*346.98*	*3.17*	
1204-In-9.1	101.89	51.94	0.51	5.03	-0.23	17.39	1.92	0.0519	4.87	0.05764	1.96872	361.23	6.92	
1204-In-10.1	*494.14*	*388.30*	*0.79*	*21.96*	*0.25*	*19.33*	*1.02*	*0.0549*	*1.52*	*0.05160*	*1.03552*	*324.31*	*3.28*	
1204-In-11.1	*761.22*	*81.72*	*0.11*	*11.62*	*0.16*	*56.29*	*1.01*	*0.0496*	*2.23*	*0.01774*	*1.01835*	*113.33*	*1.14*	
1204-In-12.1	*977.96*	*49.18*	*0.05*	*16.17*	*0.09*	*51.97*	*1.11*	*0.0492*	*2.76*	*0.01922*	*1.12693*	*122.75*	*1.37*	
1204-In-13.1	*1609.36*	*132.61*	*0.08*	*78.21*	*0.04*	*17.68*	*0.86*	*0.0540*	*1.10*	*0.05654*	*0.87580*	*354.58*	*3.02*	
1204-In-14.1	*1040.78*	*381.67*	*0.37*	*46.84*	*0.13*	*19.09*	*0.91*	*0.0541*	*1.38*	*0.05231*	*0.92111*	*328.70*	*2.95*	
Malaspina Orthogneiss (intrusive into Deep Cove Gneiss)														
1241-56.1	143.89	160.35	1.11	2.17	0.34	56.89	1.53	0.0510	4.46	0.01752	1.56008	111.95	1.73	**Age:**
1241-39.1	136.08	142.63	1.05	2.09	0.47	55.85	1.37	0.0521	4.28	0.01782	1.40255	113.86	1.58	**115.9 ± 1.2**
1241-35.1	165.60	163.73	0.99	2.57	0.93	55.33	1.36	0.0557	5.45	0.01790	1.41589	114.40	1.61	**MSWD = 1.5**
1241-32.1	126.75	140.13	1.11	2.00	2.31	54.42	1.44	0.0667	4.14	0.01795	1.49217	114.70	1.70	**n = 11**
1241-38.1	168.35	192.44	1.14	2.62	0.04	55.14	1.33	0.0486	4.16	0.01813	1.35789	115.82	1.56	
1241-52.1	161.93	172.00	1.06	2.53	-0.01	55.07	1.34	0.0482	4.19	0.01816	1.36465	116.02	1.57	
1241-57.1	148.02	153.11	1.03	2.31	-0.31	55.09	1.38	0.0459	4.50	0.01821	1.40434	116.32	1.62	
1241-50.1	206.06	229.68	1.11	3.25	0.23	54.47	1.26	0.0502	3.73	0.01832	1.28801	117.01	1.49	
1241-49.1	151.95	171.96	1.13	2.40	0.26	54.42	1.37	0.0504	6.67	0.01833	1.43805	117.09	1.67	
1241-41.1	203.17	138.82	0.68	3.21	0.01	54.32	1.28	0.0484	3.87	0.01841	1.30078	117.59	1.52	
1241-9.1	191.28	187.70	0.98	3.07	0.14	53.55	1.28	0.0496	3.77	0.01865	1.30748	119.10	1.54	
1241-6.1	*142.64*	*107.00*	*0.75*	*2.31*	*0.08*	*53.00*	*1.39*	*0.0491*	*4.46*	*0.01885*	*1.41774*	*120.39*	*1.69*	
Resolution Island Orthogneiss (trondhjemite dike)														
13204-53.1	1.23	0.03	0.03	0.02	19.86	49.97	6.75	0.2058	12.56	0.01604	2.51927	102.57	8.04	**Age:**
13204-51.1	1.05	0.01	0.01	0.01	21.02	47.71	8.26	0.2152	12.95	0.01655	2.99931	105.84	9.87	**109.4 ± 2.5**
13204-36.1	0.89	0.02	0.02	0.01	14.54	50.41	12.86	0.1637	19.95	0.01695	4.38995	108.37	14.79	**MSWD = 0.8**
13204-29.1	23.39	0.19	0.01	0.34	1.80	57.63	1.82	0.0625	5.51	0.01704	0.59885	108.93	2.03	**n = 9**
13204-30.1	11.96	0.29	0.02	0.18	1.66	57.45	1.99	0.0614	7.17	0.01712	0.66082	109.41	2.25	
13204-34.1	14.90	0.28	0.02	0.23	0.75	56.45	3.29	0.0542	6.44	0.01758	1.06154	112.37	3.71	
13204-54.1	1.03	0.01	0.01	0.02	18.74	44.57	6.89	0.1974	17.09	0.01823	2.76546	116.48	10.01	
13204-63.1	*99.97*	*113.29*	*1.13*	1.59	*0.39*	*53.95*	*1.05*	*0.0515*	*2.50*	*0.01846*	*0.33974*	*117.93*	*1.24*	
13204-78.1	1.13	2.67	2.37	0.01	47.82	43.40	6.98	0.4268	18.28	0.01202	6.42361	77.05	15.43	
13204-79.1	4.82	2.06	0.43	0.07	2.33	55.83	3.77	0.0668	21.76	0.01749	1.34755	111.79	4.68	
13204-64.1	*1.10*	*2.13*	*1.95*	*0.02*	*20.05*	*42.32*	*7.29*	*0.2079*	*20.46*	*0.01889*	*3.16451*	*120.65*	*11.86*	

Supplementary Table 2: U-Pb (zircon) SHRIMP isotopic analyses and ages.

	Concentrations					**Atomic Ratios**[i]						**Age (Ma)**		
Grain[ii]	U (ppm)	Th (ppm)	Th/U	Pb*[iii] (ppm)	*f* 206[iv] (%)	$^{238}U/^{206}Pb$[v]	% err (1□)	$^{207}Pb/^{206}Pb$[v]	% err (1□)	$^{206}Pb/^{238}U$[vi]	% err (1□)	$^{206}Pb/^{238}U$[vii]	err abs (1□)	Weighted Average age (2□)
Breaksea Orthogneiss (trondhjemite dike)														
13118A-21.1	143.94	38.53	0.27	8.09	0.11	15.27	1.36	0.0558	1.09	0.06543	0.43946	408.54	5.45	
13118A-29.1	81.35	36.48	0.45	6.05	0.06	11.53	1.27	0.0587	1.16	0.08664	0.41129	535.63	6.63	
13118A-39.1	63.78	89.31	1.40	4.85	0.06	11.29	1.57	0.0589	1.34	0.08849	0.50975	546.61	8.38	
13118A-33.1	125.25	99.31	0.79	9.79	0.04	10.99	1.12	0.0592	0.93	0.09096	0.36441	561.23	6.14	
13118A-2.1	310.81	100.85	0.32	24.81	0.05	10.75	1.26	0.0596	0.58	0.09294	0.40967	572.89	7.04	
13118A-30.1	643.89	86.66	0.13	55.62	-0.01	9.95	1.26	0.0603	0.38	0.10055	0.41050	617.66	7.58	
13118A-20.1	137.25	25.57	0.19	20.47	0.19	5.75	1.84	0.0753	0.93	0.17358	0.61430	1031.83	18.37	
13118A-15.1	46.03	51.73	1.12	6.99	-0.17	5.67	1.46	0.0729	0.97	0.17675	0.48555	1049.22	14.74	
13118A-7.1	144.56	106.46	0.74	22.61	-0.08	5.50	1.03	0.0747	0.51	0.18208	0.34300	1078.31	10.68	
13118A-18.1	113.48	48.20	0.42	17.85	-0.20	5.47	1.23	0.0739	0.60	0.18311	0.41002	1083.93	12.83	
13118A-25.1	365.45	157.46	0.43	58.49	-0.06	5.37	1.13	0.0757	0.31	0.18633	0.37826	1101.49	12.01	
13118A-22.1	157.68	46.96	0.30	26.52	-0.13	5.11	1.33	0.0772	0.49	0.19581	0.44510	1152.76	14.73	
Breaksea Orthogneiss (garnet granulite)														
1333E-32.1	*81.10*	*80.92*	*1.00*	*1.23*	*1.49*	*55.58*	*3.12*	*0.0602*	*16.48*	*0.01772*	*1.07557*	*113.25*	*3.79*	**Age:**
1333E-53.1	*25.75*	*44.21*	*1.72*	*0.40*	*1.54*	*54.94*	*1.83*	*0.0606*	*4.92*	*0.01792*	*0.59661*	*114.51*	*2.12*	**123.2 ± 1.3**
1333E-44.1	*96.68*	*79.38*	*0.82*	*1.55*	*0.27*	*53.47*	*1.28*	*0.0505*	*2.55*	*0.01865*	*0.41182*	*119.13*	*1.52*	**MSWD = 1.7**
1333E-29.1	72.70	56.74	0.78	1.17	0.28	53.03	1.25	0.0507	2.87	0.01881	0.40472	120.11	1.51	**n = 9**
1333E-47.1	115.42	132.78	1.15	1.88	0.09	52.57	1.37	0.0492	2.34	0.01901	0.43923	121.37	1.66	
1333E-13.1	117.38	132.41	1.13	1.92	0.08	52.56	1.26	0.0491	2.33	0.01901	0.40650	121.41	1.53	
1333E-25.1	109.33	127.23	1.16	1.80	-0.13	52.30	1.48	0.0475	2.40	0.01915	0.47549	122.25	1.81	
1333E-12.1	307.68	260.74	0.85	5.08	-0.06	52.10	1.20	0.0480	1.47	0.01920	0.38585	122.62	1.47	
1333E-3.1	125.52	124.24	0.99	2.09	0.03	51.49	1.24	0.0488	4.31	0.01942	0.40481	123.97	1.56	
1333E-24.1	116.53	121.82	1.05	1.95	0.11	51.19	0.99	0.0494	2.27	0.01952	0.31873	124.59	1.23	
1333E-56.1	240.47	244.28	1.02	4.05	0.16	50.91	1.19	0.0498	1.53	0.01961	0.38137	125.19	1.48	
1333E-4.1	103.27	122.57	1.19	1.75	0.46	50.58	1.05	0.0522	2.54	0.01968	0.34096	125.63	1.33	
Breaksea Orthogneiss (amphibolite)														
1333D-71.1 (rim)	0.63	0.04	0.06	0.01	39.79	51.60	6.28	0.3630	19.00	0.01167	5.03413	74.79	11.74	**Age:**
1333D-61.1 (rim)	1.81	0.03	0.02	0.02	11.07	61.84	9.90	0.1357	15.93	0.01438	3.31439	92.04	9.50	**88.8 ± 4.7**
1333D-70.2 (rim)	1.85	0.01	0.00	0.02	22.87	49.24	6.88	0.2297	18.19	0.01566	3.09692	100.19	9.65	**MSWD = 0.8**
1333D-64.1 (cor	*15.26*	*30.38*	*1.99*	*0.24*	*0.67*	*54.14*	*1.24*	*0.0537*	*7.79*	*0.01835*	*0.43087*	~~*117.21*~~	~~*1.57*~~	**n = 9**
1333D-70.1 (cor	*27.50*	*57.31*	*2.08*	*0.45*	*0.17*	*51.94*	*1.73*	*0.0499*	*5.71*	*0.01922*	*0.56444*	~~*122.73*~~	~~*2.15*~~	
1333D-44.1 (rim)	*0.55*	*0.01*	*0.01*	*0.00*	*39.49*	*68.05*	*7.31*	*0.3600*	*22.41*	*0.00889*	*5.85985*	~~*57.07*~~	~~*10.44*~~	
1333D-57.1 (rim)	6.43	0.19	0.03	0.08	5.11	67.51	4.23	0.0884	13.18	0.01406	1.43874	89.98	4.03	
1333D-21.1 (rim)	0.94	0.08	0.08	0.01	14.89	52.67	8.86	0.1664	30.73	0.01616	3.72545	103.34	11.98	
1333D-28.1 (cor	*9.36*	*15.15*	*1.62*	*0.14*	*6.64*	*54.11*	*2.21*	*0.1010*	*13.75*	*0.01725*	*0.92554*	~~*110.27*~~	~~*3.17*~~	
1333D_41.1 (rim	6.50	0.36	0.06	0.08	6.34	67.69	7.73	0.0995	20.59	0.01477	7.72800	88.59	7.21	
1333D_32.1 (rim	1.73	0.04	0.02	0.02	22.73	52.36	6.37	0.2334	25.40	0.01910	6.37043	94.44	10.67	
1333D_31.1 (rim	3.11	0.13	0.04	0.03	7.36	70.97	4.77	0.1077	24.04	0.01409	4.76627	83.61	4.89	
1333D_30.1 (rim	1.06	0.01	0.01	0.01	-6.21	104.67	14.49	-0.0034	223.91	0.00955	14.49366	~~65.09~~	~~9.42~~	
1333D_28.1 (rim	0.97	0.01	0.01	0.01	37.26	57.96	9.59	0.3516	29.23	0.01725	9.59456	~~69.41~~	~~15.38~~	
1333D_27.1 (rim	1.22	0.19	0.16	0.01	14.98	65.21	7.91	0.1700	36.77	0.01534	7.91374	83.51	9.97	

Supplementary Table 2: U-Pb (zircon) SHRIMP isotopic analyses and ages.

	Concentrations					Atomic Ratios[i]						Age (Ma)		
Grain[ii]	U (ppm)	Th (ppm)	Th/U	Pb*[iii] (ppm)	*f* 206[iv] (%)	$^{238}U/^{206}Pb$[v]	% err (1σ)	$^{207}Pb/^{206}Pb$[v]	% err (1σ)	$^{206}Pb/^{238}U$[vi]	% err (1σ)	$^{206}Pb/^{238}U$[vii]	err abs (1σ)	Weighted Average age (2σ)
Lake Chamberlain garnet orthogneiss														
1304b-42.1 (rim)	670.55	81.46	0.12	10.48	-0.18	54.29	1.15	0.0469	2.19	0.01842	1.14937	117.87	1.35	**Age:**
1304b-36.1 (rim)	818.88	91.31	0.11	12.82	0.06	54.74	0.79	0.0488	2.74	0.01827	0.79377	116.64	0.94	**117.2 ± 0.8**
1304b-49.1 (rim)	725.0278	73.2502	0.10	11.36	-0.07	54.61	0.96	0.0478	2.61	0.01831	0.95719	117.05	1.13	**MSWD = 0.9**
1304b-74.1 (rim)	542.18	60.18	0.11	8.50	0.49	54.21	0.61	0.0524	2.40	0.01845	0.61436	117.27	0.74	**n = 12**
1304b-38.1 (rim)	762.42	102.39	0.13	11.99	0.21	53.55	0.80	0.0501	2.29	0.01867	0.80004	119.02	0.96	
1304b-40.1 (rim)	686.30	116.17	0.17	10.79	-0.42	54.21	0.68	0.0450	3.33	0.01845	0.67684	118.33	0.82	
1304b-59.1 (rim)	617.11	71.20	0.12	9.71	0.08	54.00	1.10	0.0491	2.37	0.01852	1.09995	118.20	1.30	
1304b-63.1 (rim)	664.51	83.45	0.13	10.48	0.14	54.76	0.60	0.0495	2.35	0.01826	0.60413	116.50	0.72	
1304b-79.1 (rim)	849.26	133.01	0.16	13.46	0.01	54.97	0.59	0.0485	2.50	0.01819	0.59017	116.20	0.70	
1304b-51.1 (rim)	709.33	59.68	0.08	11.27	0.30	54.44	0.59	0.0509	2.35	0.01837	0.58593	116.98	0.70	
1304b-50.1 (rim)	403.08	32.34	0.08	6.41	-0.39	54.82	1.45	0.0452	2.37	0.01824	1.45145	116.97	1.69	
1304b-57.1 (rim)	762.47	113.15	0.15	12.20	-0.06	54.91	0.92	0.0479	2.22	0.01821	0.91573	116.41	1.07	

[i] Errors are reported at 1σ level and refer to last digits.

[ii] Analyses conducted on polished cross-sections of zircons embedded in epoxy. Selected zircons with 'In' in name were embedded in indium and analyzed by depth profiling exteriors.

[iii] Radiogenic 206Pb.

[iv] Fraction of total 206Pb that is common 206Pb.

[v] Uncorrected ratios.

[vi] 207Pb corrected ratios using age-appropriate Pb isotopic composition of Stacey and Kramers (1975).

[vii] 207Pb corrected age; spot analyses in italics were excluded in age calculation due to open system behavior, or presence of xenocrystic component.
Analyses reported in red refer to xenocrystic zircon populations.

Supplementary Table 3. U-Pb (zircon) geochronologic analyses by Laser-Ablation Multicollector ICP Mass Spectrometry.

				Isotopic Ratios					Apparent Ages (Ma)					
sample-grain	U (ppm)	$^{206}Pb/^{204}Pb$	U/Th	$^{207}Pb^{*}/^{235}U$	± (%)	$^{206}Pb^{*}/^{238}U$	± (%)	error corr.	$^{206}Pb^{*}/^{238}U$	± (Ma)	$^{207}Pb^{*}/^{235}U$	± (Ma)	$^{206}Pb^{*}/^{207}Pb^{*}$	± (Ma)
0649-3	523	5067	23.7	0.09544	10.3	0.01352	5.3	0.52	86.6	4.6	92.6	9.1	249.9	204.1
0649-3B	431	4260	24.6	0.09814	5.8	0.01435	3.6	0.63	91.8	3.3	95.1	5.3	177.1	105.6
0649-4	216	1608	27.8	0.09800	22.2	0.01345	8.7	0.39	86.1	7.5	94.9	20.2	321.5	469.3
0649-4B	298	2941	24.0	0.10105	8.4	0.01396	4.5	0.54	89.4	4.0	97.7	7.8	306.9	162.0
0649-5	194	1929	34.7	0.10345	9.7	0.01449	4.1	0.43	92.7	3.8	100.0	9.2	276.1	200.4
0649-6	119	1356	46.3	0.10838	16.4	0.01413	4.7	0.28	90.5	4.2	104.5	16.3	437.3	352.2
0649-7	1211	10943	7.9	0.09862	1.7	0.01408	1.3	0.74	90.2	1.1	95.5	1.6	231.2	26.2
0649-7B	115	909	29.3	0.12199	21.2	0.01399	6.3	0.30	89.6	5.6	116.9	23.4	716.2	433.5
0649-7C	80	777	43.6	0.10882	20.1	0.01414	7.2	0.36	90.5	6.5	104.9	20.0	445.6	419.8
0649-7D	79	754	44.4	0.10380	20.6	0.01404	7.3	0.35	89.9	6.5	100.3	19.7	354.4	439.4
0649-8	2700	23663	9.0	0.09297	2.8	0.01377	2.0	0.72	88.2	1.8	90.3	2.4	145.5	45.3
0649-8B	351	3380	31.2	0.10210	6.4	0.01384	4.2	0.64	88.6	3.7	98.7	6.1	350.9	111.4
0649-9	1554	11612	64.7	0.09469	3.1	0.01386	2.4	0.77	88.7	2.1	91.9	2.7	174.7	46.7
0649-9B	1484	11080	70.3	0.09757	4.9	0.01341	3.7	0.75	85.9	3.1	94.5	4.4	318.3	74.5
0649-10	1435	12204	16.7	0.09854	3.4	0.01429	3.1	0.90	91.5	2.8	95.4	3.1	195.1	35.5
0649-10C	398	3908	26.5	0.09853	7.9	0.01413	6.9	0.88	90.4	6.2	95.4	7.2	222.0	87.9
0649-11	330	3503	29.2	0.10504	13.5	0.01388	8.6	0.64	88.9	7.6	101.4	13.0	407.2	233.2
0649-12	1905	16481	8.1	0.09441	2.6	0.01391	2.3	0.88	89.0	2.0	91.6	2.3	159.3	28.1
0649-12B	2186	16994	9.0	0.09226	3.1	0.01363	2.9	0.91	87.3	2.5	89.6	2.7	151.6	30.6
0649-13	688	5949	21.6	0.09864	3.1	0.01414	2.5	0.79	90.5	2.2	95.5	2.8	222.9	44.0
0649-13B	449	3739	27.0	0.09627	4.5	0.01341	3.5	0.77	85.9	2.9	93.3	4.0	288.5	65.7

All errors are reported at the 1 sigma level and incorporate only uncertainties from measurement of isotopic ratios. U concentration and U/Th have uncertainty of ~25%. Decay constants are as follows: $^{235}U=9.8485 \times 10^{-10}$, $^{238}U=1.55125 \times 10\text{-}10$, $^{238}U/^{235}U=137.88$. Isotope ratios are corrected for Pb/U fractionation by comparison with standard zircon with an age of 564 ± 4 Ma. Initial Pb composition interpreted from Stacey and Kramers (1975), with uncertainties of 1.0 for $^{206}Pb/^{204}Pb$ and 0.3 for $^{207}Pb/^{204}Pb$.

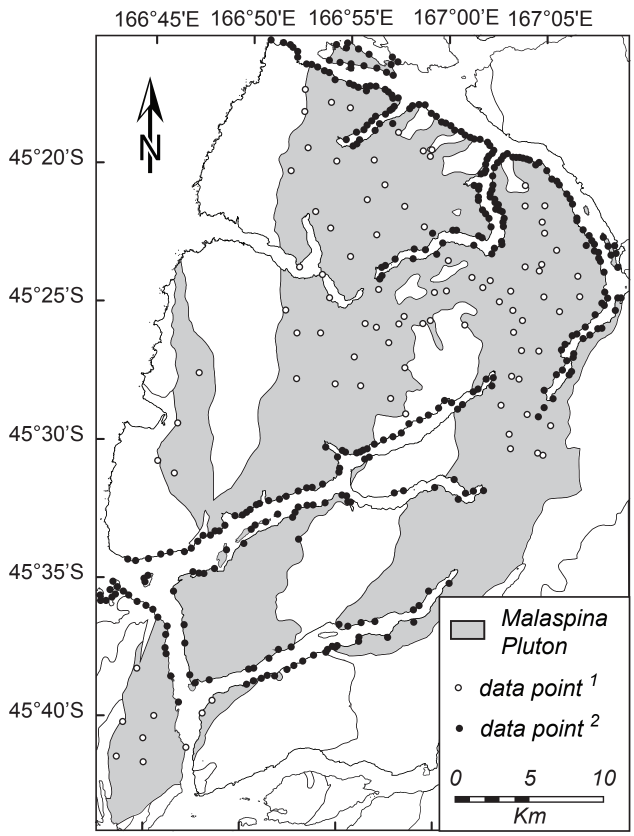
Supplementary Table 4: Zircon Rare Earth Element analyses and titanium-in-zircon temperatures.

Sample	Zircon spot	Rock Unit	Fe	Y	La	Ce	Nd	Sm	Eu	Gd	Dy	Er	Yb	Hf	Th	U	Ti48	Ti49	Dy+Er+Yb	Ti Temp	ave.	stdev
1304b	42.1	Deep Cove Gneiss	0.0	233.0	0.0	4.2	0.2	0.9	0.1	8.4	27.1	27.5	33.7	12631.9	81.5	670.5	5.9	0.0	88.3	698	670	24
1304b	36.1	Deep Cove Gneiss	0.0	227.9	0.0	4.1	0.4	1.3	0.2	11.9	33.5	20.7	18.9	12325.0	91.3	818.9	5.5	0.0	73.2	693		
1304b	49.1	Deep Cove Gneiss	0.0	406.4	0.0	4.4	0.2	1.0	0.2	9.1	41.5	51.9	62.8	12678.3	73.3	725.0	5.6	0.0	156.1	694		
1304b	74.1	Deep Cove Gneiss	10.0	157.4	0.0	3.7	0.2	0.9	0.1	6.8	17.8	19.3	25.8	12361.6	60.2	542.2	3.7	3.8	62.9	660		
1304b	38.1	Deep Cove Gneiss	0.0	204.5	0.0	4.3	0.2	1.1	0.1	11.9	29.3	18.4	17.5	12331.9	102.4	762.4	5.9	0.0	65.3	699		
1304b	40.1	Deep Cove Gneiss	0.0	630.7	0.0	6.8	0.3	1.0	0.3	11.4	56.8	103.6	198.2	11222.4	116.2	686.3	5.9	0.0	358.7	699		
1304b	59.1	Deep Cove Gneiss	5.6	325.5	0.0	3.9	0.2	1.2	0.1	12.2	38.2	37.4	44.2	12810.2	71.2	617.1	3.1	3.0	119.8	646		
1304b	63.1	Deep Cove Gneiss	7.4	276.5	0.0	4.7	0.3	1.5	0.2	14.1	36.6	29.8	34.9	12031.9	83.5	664.5	3.1	3.0	101.3	646		
1304b	79.1	Deep Cove Gneiss	6.2	445.3	0.0	6.3	0.2	1.3	0.2	14.3	49.7	61.2	87.3	11774.3	133.0	849.3	3.1	3.2	198.2	647		
1304b	51.1	Deep Cove Gneiss	16.0	284.1	0.0	4.3	0.1	0.8	0.1	6.7	28.5	42.9	67.8	12711.5	59.7	709.3	3.1	3.0	139.2	646		
1304b	50.1	Deep Cove Gneiss	6.2	61.5	0.0	3.8	0.3	1.1	0.3	8.1	10.5	5.9	6.5	11232.5	32.3	403.1	3.5	3.5	22.9	657		
1304b	57.1	Deep Cove Gneiss	23.5	425.3	0.0	6.3	0.3	0.9	0.2	9.8	42.1	66.8	120.1	12040.0	113.1	762.5	3.8	3.8	229.0	661		
1333D	71.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.3	n.d	n.d	178.2	10688.7	0.0	0.6	n.d	n.d	178.2			
1333D	61.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.2	n.d	n.d	58.5	9286.5	0.0	1.8	n.d	n.d	58.5			
1333D	70.2	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.5	n.d	n.d	245.1	8774.9	0.0	1.9	n.d	n.d	245.1			
1333D	64.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	2.2	n.d	n.d	5.7	7068.0	30.4	15.3	n.d	n.d	5.7			
1333D	70.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	4.8	n.d	n.d	4.4	7711.4	57.3	27.5	n.d	n.d	4.4			
1333D	30.1	Breaksea Orthogneiss	0.3	68.9	0.0	0.1	0.0	0.0	0.0	0.2	3.1	18.4	81.6	10669.2	0.0	1.1	1.6	1.5	103.1	598	619	60
1333D	28.1	Breaksea Orthogneiss	0.3	28.2	0.0	0.1	0.0	0.0	0.0	0.1	1.3	6.9	32.7	10870.1	0.0	1.0	1.1	1.2	40.9	573		
1333D	27.1	Breaksea Orthogneiss	0.5	20.2	0.0	0.1	0.0	0.0	0.0	0.1	1.1	4.8	18.6	10185.8	0.2	1.2	1.2	1.2	24.5	577		
1333D	31.1	Breaksea Orthogneiss	0.7	18.4	0.0	0.2	0.0	0.0	0.0	0.1	0.8	4.2	21.0	10271.8	0.1	3.1	1.1	1.1	26.1	575		
1333D	41.1	Breaksea Orthogneiss	1.2	192.5	0.0	0.1	0.0	0.0	0.0	0.5	9.3	47.3	198.6	9268.5	0.4	6.5	5.4	5.4	255.2	691		
1333D	32.1	Breaksea Orthogneiss	5.2	21.1	0.1	0.2	0.0	0.0	0.0	0.1	0.9	5.4	24.3	9519.1	0.0	1.7	6.0	6.1	30.7	701		
1333E	57.1	Breaksea Orthogneiss	n.d	20.2	0.0	0.5	0.0	0.0	0.0	0.2	2.4	4.2	14.0	10114.1	0.2	6.4	n.d	n.d	20.6			
1333E	44.1	Breaksea Orthogneiss	n.d	65.0	0.0	0.0	0.0	0.0	0.0	0.1	4.2	17.1	74.6	9762.4	0.0	0.6	n.d	n.d	96.0			
1333E	28.1	Breaksea Orthogneiss	n.d	31.1	0.0	7.3	0.1	0.2	0.1	0.7	3.7	6.7	26.8	8587.7	15.2	9.4	n.d	n.d	37.2			
1333E	21.1	Breaksea Orthogneiss	n.d	43.4	0.0	0.0	0.0	0.0	0.0	0.2	3.9	10.4	42.6	10722.6	0.1	0.9	n.d	n.d	56.9			
1333E	56.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	20.6	n.d	n.d	142.6	8389.9	244.3	240.5	n.d	n.d	142.6			
1333E	53.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	2.5	n.d	n.d	4.1	6350.0	44.2	25.7	n.d	n.d	4.1			
1333E	47.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	23.3	n.d	n.d	125.9	8588.8	132.8	115.4	n.d	n.d	125.9			
1333E	44.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	11.3	n.d	n.d	62.4	7603.1	79.4	96.7	n.d	n.d	62.4			
1333E	32.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	7.6	n.d	n.d	61.6	6691.7	80.9	81.1	n.d	n.d	61.6			
1333E	29.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	5.2	n.d	n.d	58.3	8746.3	56.7	72.7	n.d	n.d	58.3			
1333E	25.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	22.1	n.d	n.d	122.0	8288.6	127.2	109.3	n.d	n.d	122.0			
1333E	24.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	22.0	n.d	n.d	130.1	7728.3	121.8	116.5	n.d	n.d	130.1			
1333E	13.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	22.1	n.d	n.d	128.6	8669.9	132.4	117.4	n.d	n.d	128.6			
1333E	12.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	13.5	n.d	n.d	144.3	9410.4	260.7	307.7	n.d	n.d	144.3			
1333E	4.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	22.8	n.d	n.d	123.4	8465.5	122.6	103.3	n.d	n.d	123.4			
1333E	3.1	Breaksea Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	8.1	n.d	n.d	86.1	8816.3	124.2	125.5	n.d	n.d	86.1			
13204	63.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	18.9	n.d	n.d	112.9	7915.8	113.3	100.0	n.d	n.d	112.9			
13204	54.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.1	n.d	n.d	5.4	10883.8	0.0	1.0	n.d	n.d	5.4			
13204	51.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.1	n.d	n.d	4.6	10923.6	0.0	1.1	n.d	n.d	4.6			
13204	53.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.1	n.d	n.d	1.6	11947.3	0.0	1.2	n.d	n.d	1.6			
13204	36.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.1	n.d	n.d	3.2	12040.5	0.0	0.9	n.d	n.d	3.2			
13204	34.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	1.1	n.d	n.d	18.5	7568.3	0.3	14.9	n.d	n.d	18.5			

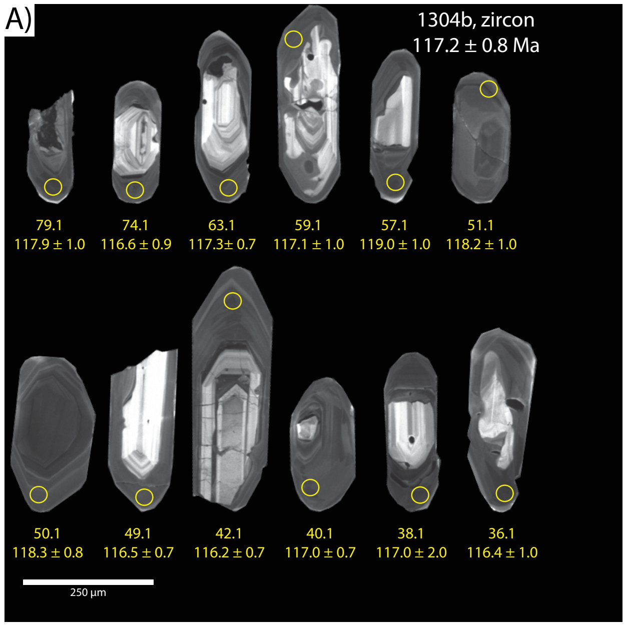
13204	30.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	0.9	n.d	n.d	14.5	7728.0	0.3	12.0	n.d	n.d	14.5
13204	29.1	Resolution Orthogneiss	n.d	n.d	n.d	n.d	n.d	n.d	n.d	1.1	n.d	n.d	26.4	9533.1	0.2	23.4	n.d	n.d	26.4
13118A	39.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	18.2	n.d	n.d	138.9	8058.2	89.3	63.8	n.d	n.d	138.9
13118A	33.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	12.3	n.d	n.d	14.0	11942.3	99.3	125.3	n.d	n.d	14.0
13118A	30.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	27.0	n.d	n.d	32.6	11154.2	86.7	643.9	n.d	n.d	32.6
13118A	29.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	8.9	n.d	n.d	80.3	9667.4	36.5	81.4	n.d	n.d	80.3
13118A	25.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	128.9	n.d	n.d	722.9	8016.5	157.5	365.4	n.d	n.d	722.9
13118A	22.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	19.4	n.d	n.d	205.3	8696.8	47.0	157.7	n.d	n.d	205.3
13118A	21.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	12.2	n.d	n.d	28.7	10008.9	38.5	143.9	n.d	n.d	28.7
13118A	20.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	10.5	n.d	n.d	112.8	9282.6	25.6	137.3	n.d	n.d	112.8
13118A	18.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	16.1	n.d	n.d	195.9	8887.5	48.2	113.5	n.d	n.d	195.9
13118A	15.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	32.4	n.d	n.d	202.9	8283.6	51.7	46.0	n.d	n.d	202.9
13118A	7.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	12.2	n.d	n.d	174.6	9772.4	106.5	144.6	n.d	n.d	174.6
13118A	2.1	Malaspina Pluton	n.d	n.d	n.d	n.d	n.d	n.d	n.d	61.7	n.d	n.d	70.1	10480.3	100.9	310.8	n.d	n.d	70.1
1254	1.1	Malaspina Pluton	n.d	673.6	0.0	0.2	0.0	0.1	0.2	2.5	36.9	143.8	397.7	10217.8	0.9	66.8	n.d	n.d	578.4
1254	3.1	Malaspina Pluton	n.d	1125.4	0.0	1.1	0.1	0.5	0.3	8.4	76.3	236.0	619.0	12236.4	4.1	31.3	n.d	n.d	931.4
1254	4.1	Malaspina Pluton	n.d	83.8	0.0	0.2	0.0	0.0	0.0	0.5	5.5	14.6	37.2	19950.2	0.0	6.1	n.d	n.d	57.3
1254	10.1	Malaspina Pluton	n.d	1331.7	0.0	1.3	0.1	1.3	0.2	34.9	123.0	83.7	109.8	89411.7	3.8	1438.0	n.d	n.d	316.6
1254	16.1	Malaspina Pluton	n.d	91.6	0.0	0.2	0.0	0.1	0.0	0.4	5.4	18.1	60.1	20377.7	0.0	3.8	n.d	n.d	83.7
1254	21.1	Malaspina Pluton	n.d	256.7	0.0	10.3	0.6	1.1	0.5	7.4	24.2	41.9	81.9	9015.8	56.4	110.1	n.d	n.d	147.9
1254	24.1	Malaspina Pluton	n.d	5877.2	0.0	26.2	0.9	5.1	2.0	85.6	480.4	675.6	1101.8	34095.5	66.6	1488.8	n.d	n.d	2257.9
1254	29.1	Malaspina Pluton	n.d	391.7	0.1	12.3	1.3	2.1	0.6	12.9	41.8	65.3	115.9	9821.1	128.7	136.8	n.d	n.d	223.0
1254	40.1	Malaspina Pluton	n.d	555.4	0.1	0.7	0.0	0.3	0.2	8.9	54.9	27.1	16.6	51479.1	1.9	405.2	n.d	n.d	98.6
1254	41.1	Malaspina Pluton	n.d	598.2	0.0	12.9	0.7	2.0	0.5	17.0	60.2	103.1	181.3	11046.5	116.7	140.0	n.d	n.d	344.5
1254	43.1	Malaspina Pluton	n.d	4310.4	1.7	0.3	0.1	0.7	0.4	20.5	255.0	718.6	1796.7	20579.0	5.8	353.8	n.d	n.d	2770.2
1254	45.1	Malaspina Pluton	n.d	306.5	0.0	0.5	0.0	0.2	0.1	7.7	35.0	16.0	29.8	61783.7	1.7	810.7	n.d	n.d	80.8
1254	48.1	Malaspina Pluton	n.d	654.0	0.0	0.9	0.1	0.4	0.3	14.3	72.6	26.0	28.2	48806.3	8.4	698.8	n.d	n.d	126.8
1256	1.1	Malaspina Pluton	n.d	5966.9	0.0	40.0	5.9	24.7	7.7	281.2	742.5	379.1	290.1	34215.2	233.7	3439.8	n.d	n.d	1411.7
1256	4.1	Malaspina Pluton	n.d	544.5	0.0	1.0	0.0	0.4	0.2	5.7	41.3	61.4	97.9	19733.7	2.2	107.4	n.d	n.d	200.6
1256	7.1	Malaspina Pluton	n.d	991.7	0.0	0.4	0.0	0.2	0.2	4.7	57.0	164.2	392.7	15419.4	0.2	23.4	n.d	n.d	613.9
1256	16.1	Malaspina Pluton	n.d	1296.3	0.0	1.9	0.1	0.5	0.6	9.2	81.2	256.4	690.2	13800.7	5.0	124.5	n.d	n.d	1027.9
1256	17.1	Malaspina Pluton	n.d	1716.7	0.0	1.7	0.1	0.7	0.7	12.9	116.7	340.0	838.9	11387.4	4.9	141.4	n.d	n.d	1295.6
1256	18.1	Malaspina Pluton	n.d	991.6	0.0	0.8	0.0	0.2	0.3	6.4	61.4	205.3	559.3	10806.6	2.0	72.2	n.d	n.d	825.9
1256	29.1	Malaspina Pluton	n.d	2878.4	0.0	17.5	1.2	7.0	2.6	98.4	330.6	192.8	161.5	30997.8	63.4	1159.8	n.d	n.d	685.0
1256	33.1	Malaspina Pluton	n.d	1186.5	0.0	0.4	0.0	0.3	0.3	6.6	71.7	220.8	554.3	13595.7	0.4	27.0	n.d	n.d	846.9
1256	34.1	Malaspina Pluton	n.d	1518.9	0.0	2.4	0.1	0.4	0.6	10.0	97.9	314.0	861.4	16816.8	3.4	96.7	n.d	n.d	1273.4
1256	46.1	Malaspina Pluton	n.d	957.3	0.0	1.3	0.1	0.4	0.4	6.0	60.0	196.7	530.6	14046.3	3.3	88.4	n.d	n.d	787.3
1256	47.1	Malaspina Pluton	n.d	359.9	0.0	0.4	0.0	0.1	0.1	3.0	24.2	43.8	100.8	26715.1	0.3	40.7	n.d	n.d	168.8
1256	48.1	Malaspina Pluton	n.d	5979.2	0.0	16.2	2.4	12.7	5.1	178.0	632.4	413.5	372.5	28008.4	11.0	407.5	n.d	n.d	1418.5
1256	49.1	Malaspina Pluton	n.d	455.8	0.1	0.3	0.0	0.1	0.1	2.2	27.8	83.6	240.6	12714.8	2.1	140.3	n.d	n.d	352.0
1204	3.1	Deep Cove Gneiss	n.d	619.0	0.0	21.7	1.2	2.1	0.8	13.9	54.5	109.1	229.5	9127.8	120.7	230.0	n.d	n.d	393.2
1204	3.2	Deep Cove Gneiss	n.d	266.8	0.4	15.7	0.1	0.4	0.1	3.7	19.2	48.5	140.6	12905.7	90.9	856.8	n.d	n.d	208.2
1204	5.1	Deep Cove Gneiss	n.d	956.7	0.0	22.1	2.8	4.8	2.0	28.1	91.6	158.5	300.1	8950.1	171.3	243.9	n.d	n.d	550.3
1204	5.2	Deep Cove Gneiss	n.d	242.0	0.6	7.6	0.1	0.2	0.1	2.5	16.7	45.3	136.2	11482.4	61.5	1091.1	n.d	n.d	198.2
1204	6.1	Deep Cove Gneiss	n.d	452.7	0.0	23.4	0.2	0.5	0.2	5.7	29.7	82.7	247.4	13452.0	314.3	1468.2	n.d	n.d	359.8
1204	7.1	Deep Cove Gneiss	n.d	608.7	0.0	36.0	0.7	1.8	0.7	12.3	51.0	108.5	229.1	10407.6	279.0	551.4	n.d	n.d	388.6
1204	11.1	Deep Cove Gneiss	n.d	505.4	0.7	30.0	0.3	0.8	0.2	8.0	40.4	96.3	248.6	12958.9	222.5	1597.5	n.d	n.d	385.4
1204	11.2	Deep Cove Gneiss	n.d	707.3	0.0	24.4	0.9	1.7	0.7	13.5	57.8	125.0	277.2	9571.3	147.5	321.3	n.d	n.d	459.9
1204	12.1	Deep Cove Gneiss	n.d	393.3	0.0	21.2	0.3	0.9	0.2	6.3	30.2	73.6	189.7	13640.7	135.5	931.3	n.d	n.d	293.4

1204	14.1	Deep Cove Gneiss	n.d	323.2	2.0	21.3	0.3	0.5	0.1	4.9	24.1	58.5	149.7	10587.6	114.5	905.4	n.d	n.d	232.3
1204	16.1	Deep Cove Gneiss	n.d	294.1	0.7	14.5	0.2	0.2	0.1	3.5	21.8	57.3	160.7	13076.1	98.7	876.9	n.d	n.d	239.8
1204	17.1	Deep Cove Gneiss	n.d	359.1	0.0	19.1	0.1	0.5	0.1	4.3	25.4	67.4	192.5	14064.5	127.3	1283.2	n.d	n.d	285.3
1204	17.2	Deep Cove Gneiss	n.d	458.8	0.0	18.5	0.6	1.3	0.6	10.2	39.1	78.4	175.3	9612.9	99.3	226.6	n.d	n.d	292.9
1204	21.1	Deep Cove Gneiss	n.d	511.0	0.1	29.2	0.3	0.8	0.1	7.2	39.1	96.9	242.1	13906.8	175.4	1407.0	n.d	n.d	378.1
1204	36.1	Deep Cove Gneiss	n.d	243.7	1.0	8.0	0.1	0.1	0.1	2.8	16.6	45.2	146.6	14685.7	55.3	1379.7	n.d	n.d	208.5
1204	38.1	Deep Cove Gneiss	n.d	853.2	0.0	35.2	0.9	1.7	0.7	14.9	69.2	160.0	363.2	10538.8	202.7	529.3	n.d	n.d	592.5
1204	53.1	Deep Cove Gneiss	n.d	791.2	0.0	20.8	1.8	2.9	1.2	19.5	72.3	135.7	280.9	9633.0	156.2	279.4	n.d	n.d	489.0
1204	55.1	Deep Cove Gneiss	n.d	209.3	0.1	7.1	0.0	0.2	0.1	2.2	11.8	38.6	137.7	13529.2	105.3	1322.6	n.d	n.d	188.0
1204	59.1	Deep Cove Gneiss	n.d	578.1	0.0	22.9	0.5	1.3	0.6	10.7	46.5	105.6	244.7	9998.6	115.7	288.5	n.d	n.d	396.8
1204	59.2	Deep Cove Gneiss	n.d	293.1	0.2	5.3	0.0	0.2	0.1	3.0	19.3	55.6	180.7	13846.0	32.6	1304.5	n.d	n.d	255.6
1204	69.1	Deep Cove Gneiss	n.d	117.7	0.3	4.0	0.1	0.1	0.1	1.0	6.9	22.1	71.1	10521.2	43.0	509.1	n.d	n.d	100.1
1204	72.1	Deep Cove Gneiss	n.d	654.0	0.0	28.9	0.3	0.8	0.2	8.2	46.9	123.9	391.6	17756.8	269.5	2986.6	n.d	n.d	562.3
1204	72.2	Deep Cove Gneiss	n.d	612.1	0.2	25.7	0.8	1.3	0.5	11.9	48.4	107.8	245.8	9926.8	145.0	350.2	n.d	n.d	402.0
1241	6.1	Malaspina Pluton	n.d	433.2	0.0	14.4	0.5	1.2	0.3	10.5	39.7	73.6	144.8	10683.6	102.3	147.1	n.d	n.d	258.1
1241	9.1	Malaspina Pluton	n.d	894.2	0.4	15.3	4.3	6.4	1.4	32.4	94.2	147.4	244.1	8848.6	181.4	198.3	n.d	n.d	485.7
1241	32.1	Malaspina Pluton	n.d	763.5	0.2	15.0	4.4	6.2	1.4	31.3	85.4	122.5	203.3	8882.4	138.7	134.7	n.d	n.d	411.2
1241	35.1	Malaspina Pluton	n.d	803.8	0.2	15.6	4.6	6.2	1.4	32.9	88.1	131.4	216.4	8919.2	161.8	173.7	n.d	n.d	435.9
1241	38.1	Malaspina Pluton	n.d	862.2	0.1	18.1	3.5	6.0	1.3	34.7	97.9	143.1	234.6	10306.7	185.5	174.8	n.d	n.d	475.6
1241	39.1	Malaspina Pluton	n.d	747.3	0.3	14.8	4.5	5.7	1.3	30.1	83.2	121.0	198.5	8387.5	144.0	146.5	n.d	n.d	402.7
1241	41.1	Malaspina Pluton	n.d	364.8	0.0	16.8	0.5	1.1	0.3	8.6	33.4	62.6	124.0	10669.7	134.6	208.9	n.d	n.d	220.0
1241	49.1	Malaspina Pluton	n.d	809.3	0.0	16.8	3.4	5.7	1.2	33.8	92.4	132.6	220.4	9936.4	166.7	157.8	n.d	n.d	445.4
1241	50.1	Malaspina Pluton	n.d	926.7	0.0	20.7	3.1	5.9	1.4	36.0	105.1	154.2	258.2	10810.1	221.0	213.8	n.d	n.d	517.5
1241	52.1	Malaspina Pluton	n.d	766.2	0.0	15.1	1.2	3.4	0.7	25.2	81.0	127.4	215.1	10015.8	171.6	173.4	n.d	n.d	423.5
1241	56.1	Malaspina Pluton	n.d	779.8	0.0	14.7	2.3	4.9	1.1	29.5	85.6	127.4	213.0	9809.9	154.6	148.2	n.d	n.d	426.0
1241	57.1	Malaspina Pluton	n.d	711.2	0.0	13.6	1.4	3.3	0.8	22.0	75.6	119.7	203.1	10260.2	149.4	155.4	n.d	n.d	398.4

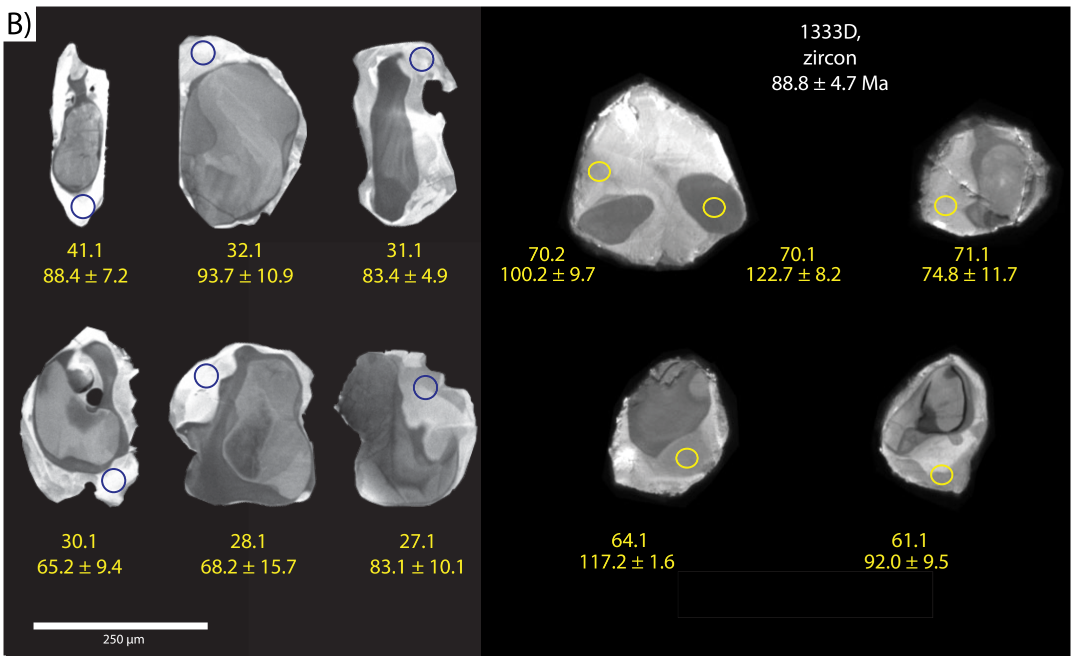
n.d. = not determined

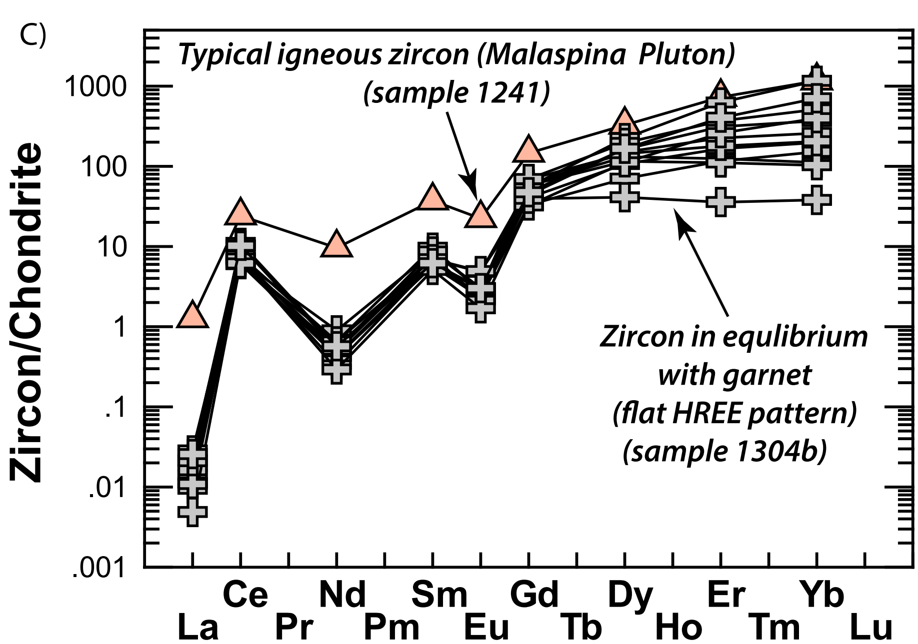


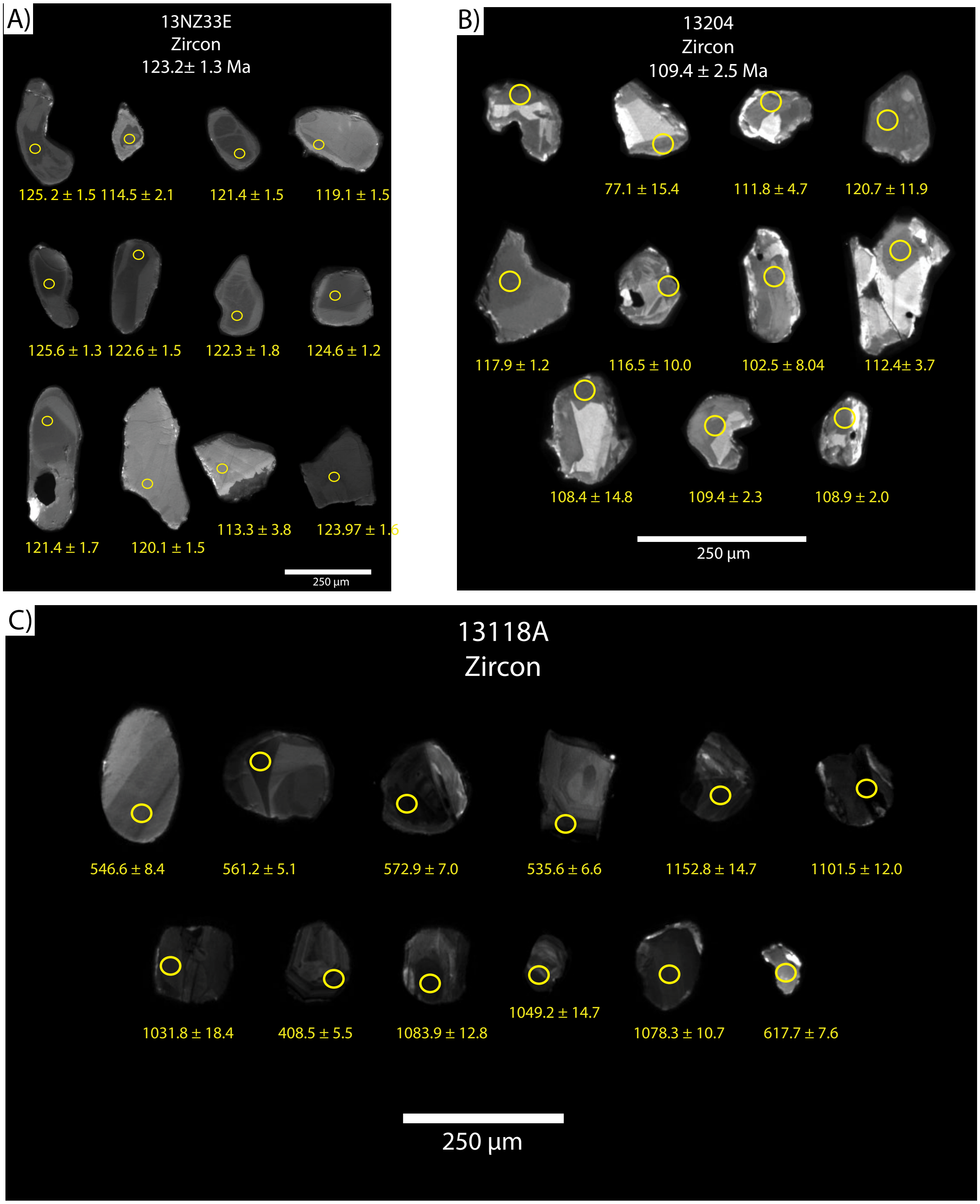
Supplemental Figure S1: Map showing the extent of data points used to construct maps of the Malaspina Pluton (shaded gray). Superscripts in the key indicate data sources: 1—Turnbull et al. (2010) (white dots), 2—this study (black dots).



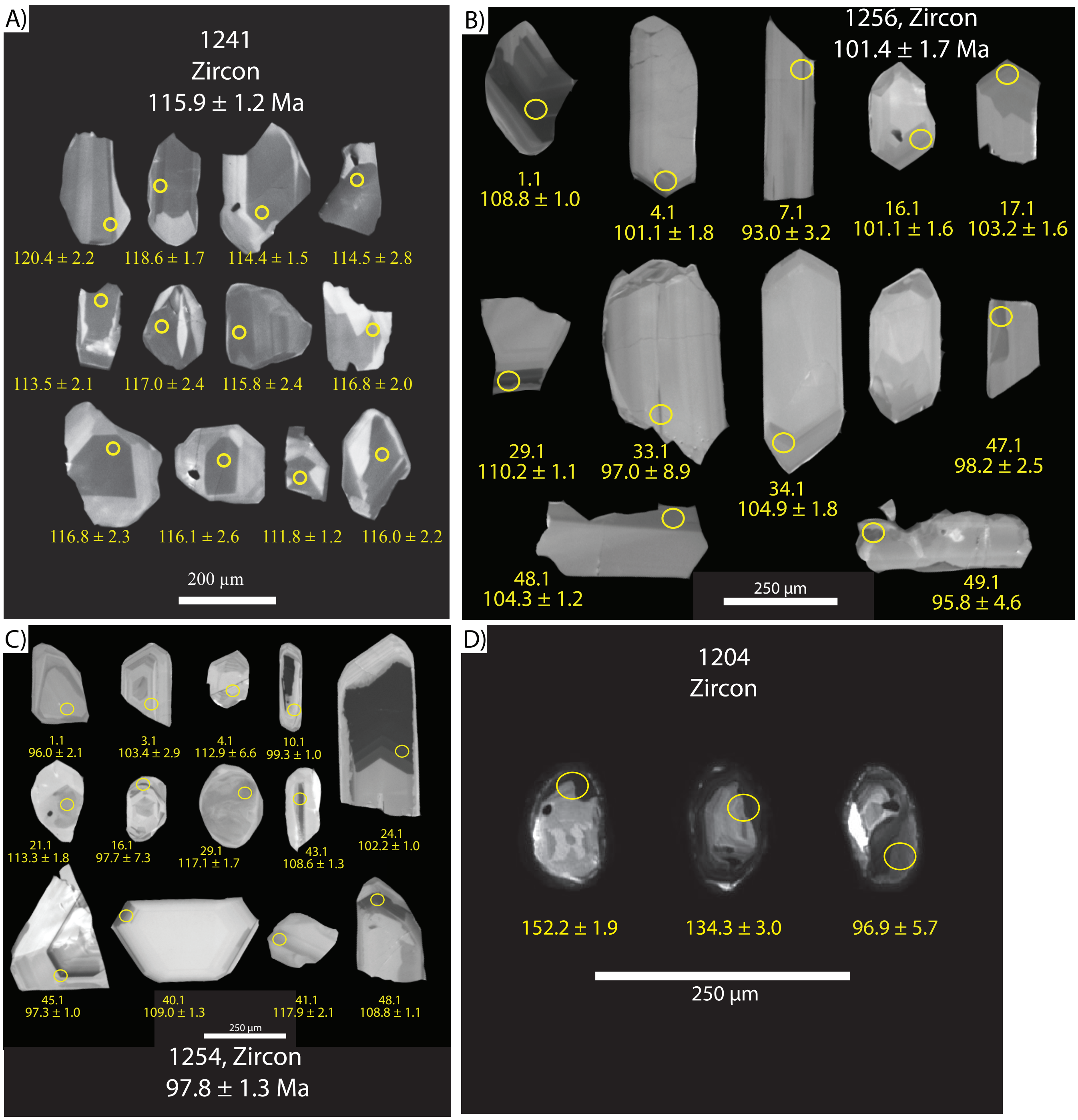
Supplemental Figure S2: Scanning electron microscope cathodoluminescence images of zircon in samples (A) 1304b and (B) 1333D. (C) Comparison of chondrite-normalized rare earth element abundances for zircon in samples 1304b (metamorphic) and 1241 (igneous).



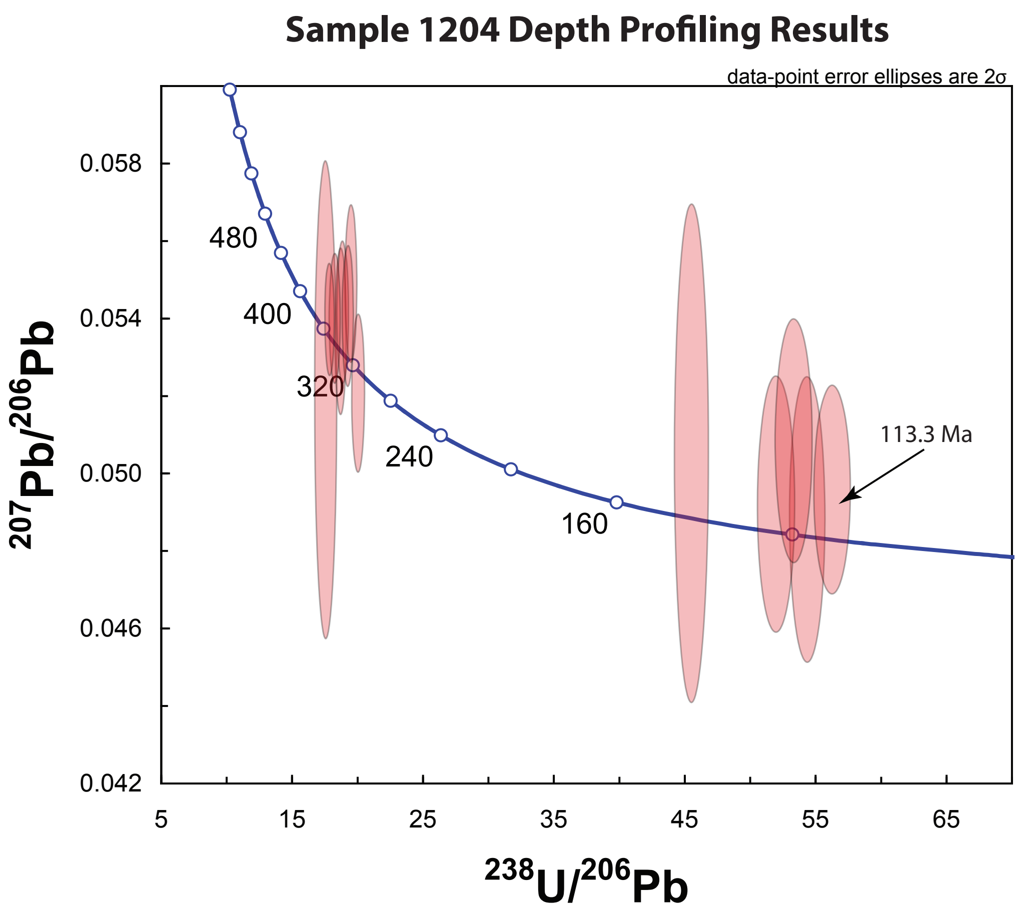




Supplemental Figure S3: Scanning electron microscope cathodoluminescence images of zircon in samples (A) 1333E, (B) 13204, and (C) 13118A.



Supplemental Figure S4: Scanning electron microscope cathodoluminescence images of zircon in samples (A) 1241, (B) 1256, (C) 1254, and (D) 1204.



Supplemental Figure S5: Results of depth profiling in zircon from sample 1204.