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An Archean Yellowstone? Evidence from extremely low $\delta^{18}O$ in zircons preserved in granulites of the Yilgarn Craton, Western Australia

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1 Methods

1.1 Whole rock Geochemistry

Samples for whole-rock geochemical analyses were powdered using a tungsten-carbide ring mill. Whole rock samples were analyzed at the Intertek Genalysis Laboratory Services, Australia, following a customized litho-geochemical package (LITH/204x). Major elements were analyzed via XRF, and FeO was determined via acid digestion and titration. Trace elements were quantified by ICP-OES and ICP-MS via dissolution of fused borate lithium glass. Acid digestion of rock powder, followed by ICP-OES and ICP-MS, was used to quantify Co, Ni, Cu, Zn, Li, and Pb. The relative analytical error for major and trace elements is 1% and 1–8%, respectively, and for elements with very low concentrations (lower than 0.1 ppm) up to 10%. Detection limits for all the analyzed elements as well as the results of the analyzed internal standard material BB1 and KG1 (Morris, 2007) are given in table DR1

1.2 U-Pb and O isotope analysis in zircons

Zircon was extracted from each sample via standard procedures, mounted in epoxy, polished, and imaged by CL techniques. U-Pb isotope data were acquired via SHRIMP II at

Curtin University, Australia. Oxygen isotope analyses were performed at CMCA at the University of Western Australia using a CAMECA 1280 SIMS.

1.2.1 U-Pb geochronology via SHRIMP II

The zircons in this study were dated by SHRIMP II at Curtin University, Perth, following techniques described by De Laeter and Kennedy (1998), Kennedy and De Laeter (1998), and Nelson et al. (1997). All analyses were performed on the optically clearest, fracture- and inclusion-free parts within cores and rims. The (U–Th)–Pb isotope dataset is given in Supplementary Table DR2. All $^{207}Pb/^{206}Pb$ zircon ages referred to in this study have been corrected for common Pb by measurement of ^{204}Pb and assuming a composition of common Pb following Compston et al. (1984). Zircon reference material M257 ($^{206}Pb/^{238}U$ age = 561.3 ± 0.6 Ma; Nasdala et al., 2008) was used as the primary standard, while OGC zircons ($^{207}Pb/^{206}Pb$ age = 3465.4 ± 0.6 Ma, Stern et al., 2009) were routinely analyzed to monitor analytical precision and accuracy of $^{207}Pb/^{206}Pb$ ratios (Table DR3). The data were reduced via the software packages Isoplot and Squid (Ludwig, 2003; 2009).

1.2.2 Oxygen isotopes via SIMS (Cameca 1280)

In-situ oxygen isotope compositions ($^{18}O/^{16}O$) were measured using a SIMS (Cameca IMS-1280) at the Centre for Microscopy, Characterisation and Analysis (CMCA), University of Western Australia (UWA). A ~ 2.5 nA focused Cs+ primary beam was operated at 10 kV and the secondary ion beam was extracted at -10 kV. The analysis area was pre-sputtered using a 15 × 15 µm raster for 40 seconds, followed by automated secondary centering in the field aperture (FA; 3000 µm) and entrance slit (ES; 150 µm). The analysis used a 10 × 10 µm raster employing dynamic transfer at a 100 × field magnification for 12 × 4 second integrations. Two oxygen isotopes were measured simultaneously using multicollection

Faraday Cup (FC) detectors with amplifiers of 10^{10} Ω resistor for ^{16}O and 10^{11} Ω for ^{18}O. An exit slit of 500 μm was used on each of the multicollector detectors, providing a nominal mass resolving power (MRP) of ca. 2500. The magnetic field was regulated using nuclear magnetic resonance (NMR). A normal incidence electron gun was used for charge compensation for all analyses. Typical ^{16}O and ^{18}O count rates were 1.8×10^9 and 3.5×10^6 cps, respectively. The average external precisions (2 SD) for standard analyses of Penglai ($\delta^{18}O = 5.31 \pm 0.1$ ‰; Li et al., 2010) and Temora 2 (e.g., $\delta^{18}O$ 8.2 ‰, Black et al., 2004) zircon were ≤ 0.5 ‰ (Table DR4), except for session 4 in which small spot sizes were used.

In order to test if post-crystallization alteration influenced the ^{18}O signatures of the zircons, we measured $^{16}O^1H/^{16}O$ in rims and cores of the strongly ^{18}O depleted TKN58 zircons. The analytical conditions remained the same except for the following adjustments: To fit several SIMS spots on to the rim, a small Gaussian beam was tuned to achieve a spot size of less than 3 μm. The primary beam intensity was kept at ~100 pA. Prior to analysis, the mount was coated with thin (10 nm) Au and then degassed for a week in the IMS-1280 storage. A liquid nitrogen cold trap was used during the analyses to decrease the background H_2O level to as low as possible. A 5 μm raster beam was used for 60 s pre-sputter, followed by a 2 μm raster for the measurement. A small field aperture (2000 μm) was used to decrease the electron induced secondary ions from outside of the running spot. Higher mass resolution was achieved to resolve the $^{16}O^1H$ peak from the ^{17}O peak, by using a narrow entrance slit (60 μm) and an exit slit of 200 μm. The nominal resolving power was ~6000 (by Cameca definition). ^{16}O and OH were collected with FCs with a 10^{11} ohm resistor, and ^{18}O was collected simultaneously with an electron multiplier (EM). The EM high voltage was optimised at the beginning of the session. Average count rates were 2.1×10^7, 4.2×10^4 and 4.2×10^4 cps for ^{16}O, OH and ^{18}O, respectively. Each analysis comprised a total of 60 cycles (10 cycles x 6 blocks) with 4 seconds of counting time per cycle. Three zircon reference materials (Temora 2, Penglai, M257) were measured throughout the analytical session to check analysis accuracy/precision and background OH/O level, assuming that they have negligible OH content. The measured OH/O ratios of the sample are corrected for the drift and background determined from the zircon reference material. The OH/O ratios measured in both the rim and the core of TKN58 zircon are low and only slightly higher than those of standards except from spots impinging on micro cracks (Table DR5). This indicates that the depleted oxygen compositions of the zircon in this study were not affected by post-crystallization aqueous alteration, but represent primary signatures. This is further supported by the REE pattern of zircon cores and rims that resemble those of typical unaltered zircons (Fig. DR7)

1.2.3. Rare earth element (REE) analysis in zircons via LA-ICP-MS

Zircons in grain mounts were analyzed by LA-ICP-MS at the University Western Australia, Perth, Australia. LA-ICP-MS analysis was performed using an X-series II quadrupole ICP-MS attached to an Analyte G2 Excimer laser system (193 nm wavelength) with a standard dual volume cell. The He carrier gas was set at 0.9 l/min (MFC1= 0.6 l/min and MFC2= 0.4 l/min) and was mixed with a nebulizer flow of argon (0.7 l/min) in a glass mixing bulb. A steady flow of ~5 ml/min N_2 was added in order to enhance sensitivity and reduce oxide production before being introduced into the plasma. The mass spectrometer was tuned to maximum sensitivity at plasma conditions of Th/U ~ 1 in a NIST610 glass, and the production of molecular oxide species was monitored by maintaining a low ThO^+/Th^+ ratio ~0.25%. The laser ablation repetition rate was 10 Hz, with a laser fluence of 5J/cm^2. A spot size of 25 or 35 micrometers was used for the unknowns and 35 and 40 micrometer spot sizes were used for standard reference material NIST610 and NIST612, respectively. The dwell time for each element was set at 20ms. A 30 s background was collected prior to each analysis. Element concentrations were reduced with the Iolite software package (Hellstrom et al., 2008) using bracketing analysis of NIST610 as an external standard with the reference concentrations taken from Jochum et al. (2011). SiO_2 (31.57 wt.%) was used as the internal standard values for each analyzed grain and NIST612 was analyzed and used as a secondary standard (Table DR6).

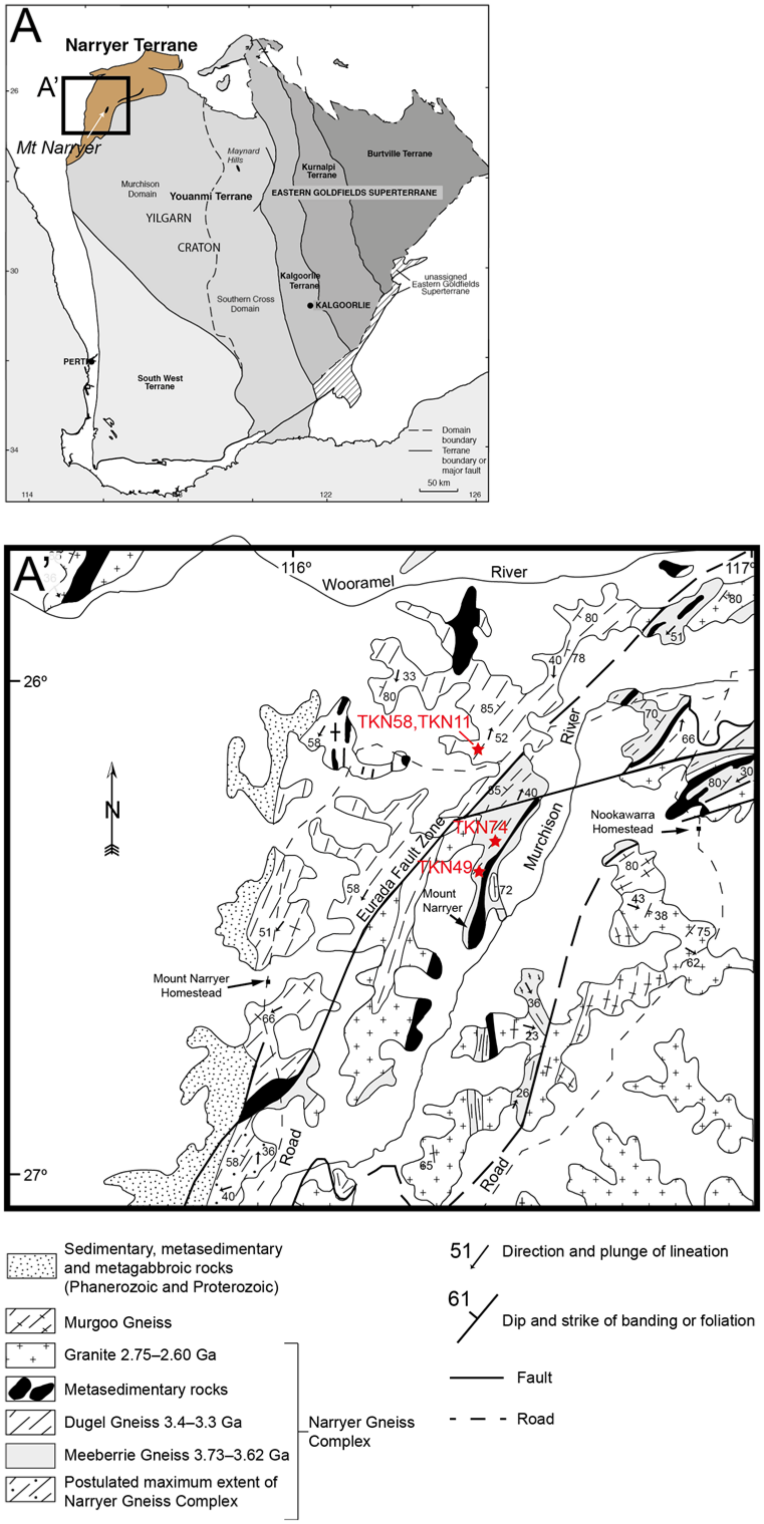


Figure DR1: Regional overview of the location of the Archean Narryer Terrane (modified from Wilde and Spaggiari, 2007). A`) Detailed geology of the sample location, modified from Ho et al. (1990).

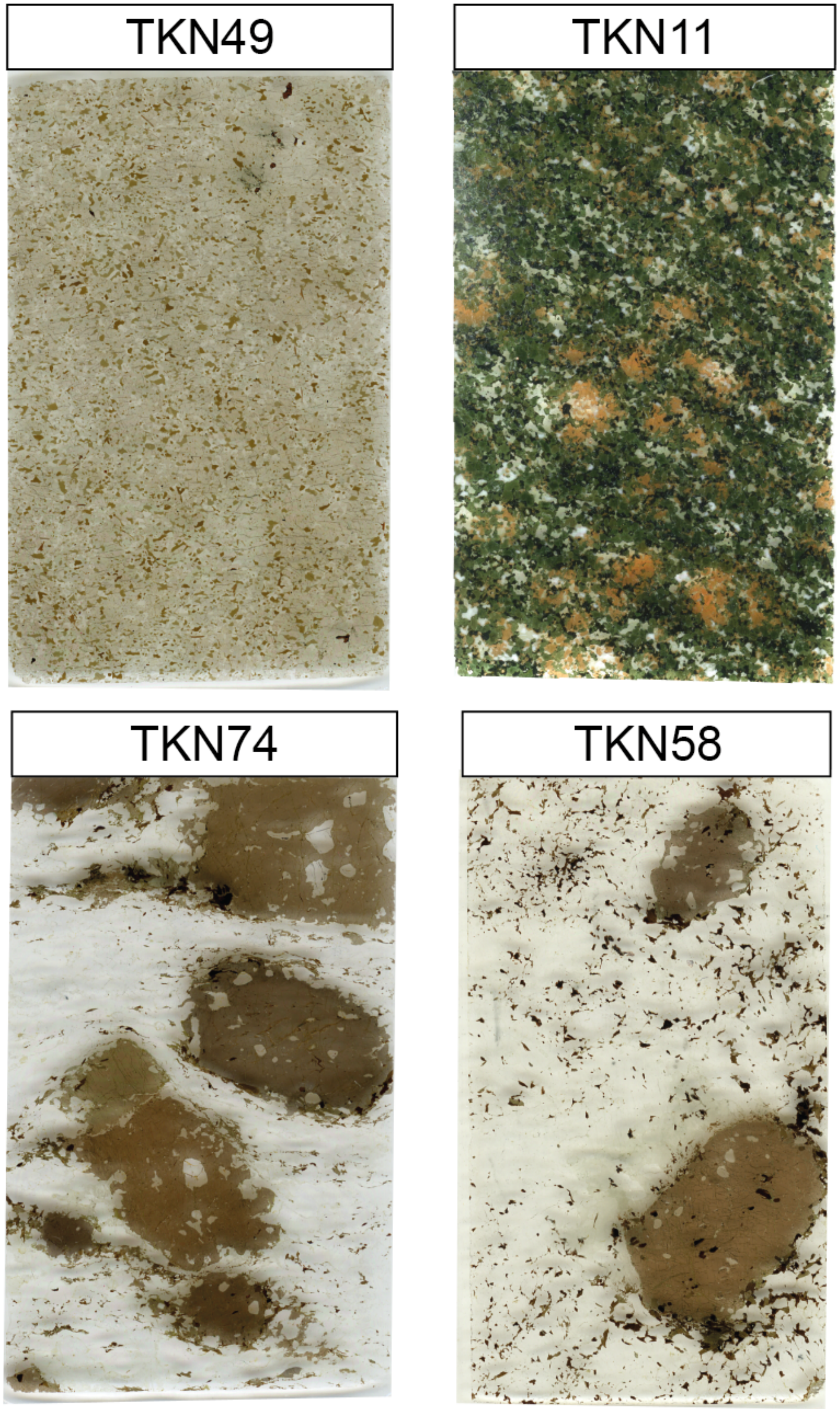


Figure DR2: Scanned polished thin sections. TKN49 and TKN11 represent mafic granulite. TKN58 and TKN74 contain large euhedral orthopyroxenes.

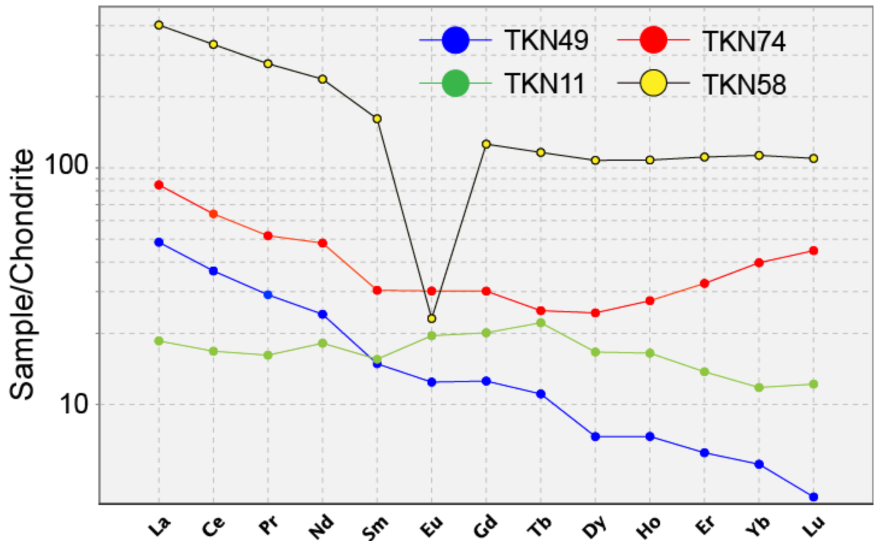


Figure DR3: Chondrite normalized REE pattern of the studied granulites (chondrite reference values are from McDonough and Sun, 1995).

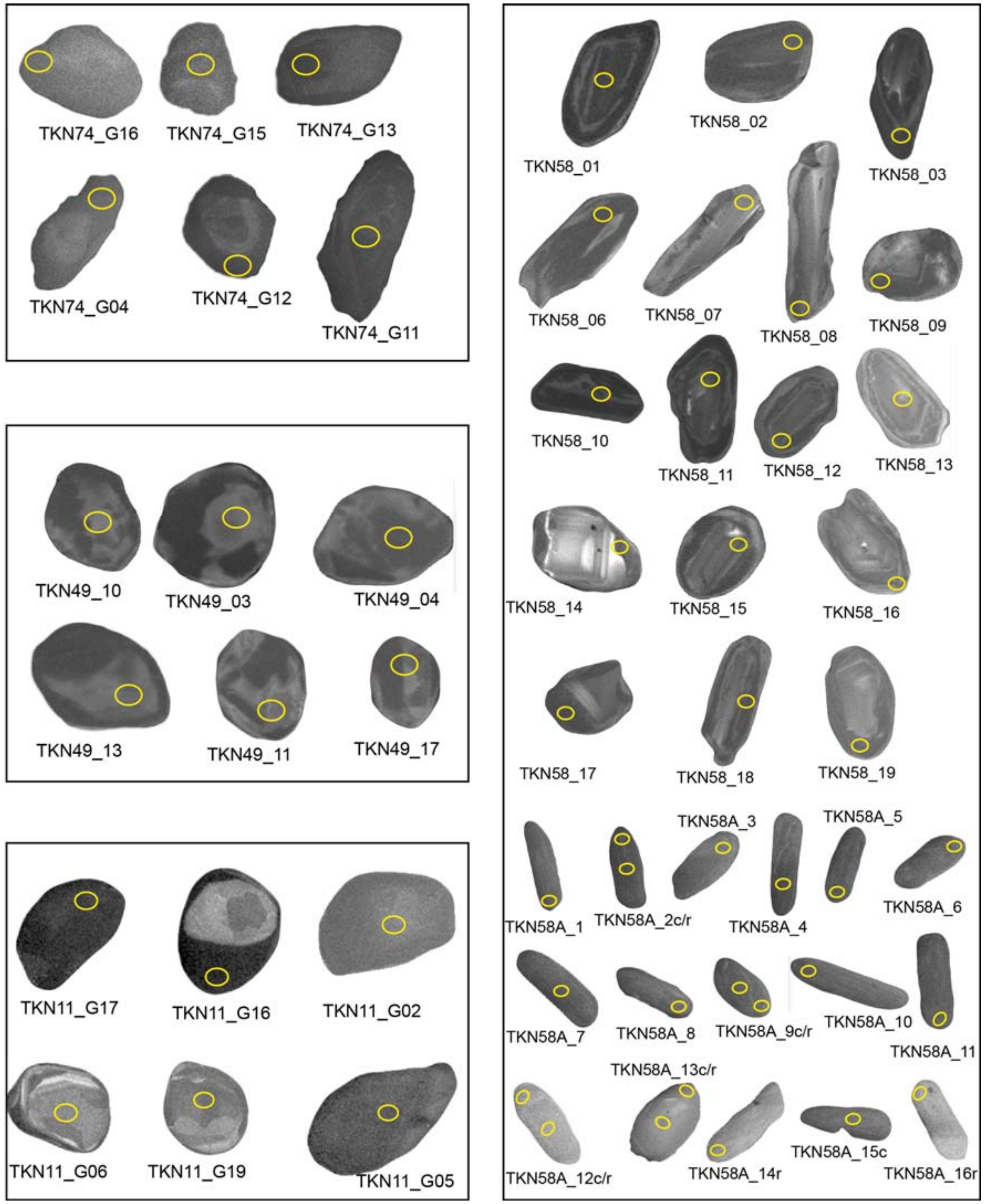


Figure DR4: Representative CL-images of zircons from the studied samples TKN74, TKN49, and TKN11 as well as all analyzed zircons from sample TKN58. Yellow ellipses (~20 µm) show the spot locations for U-Pb analyses by SHRIMP II and oxygen isotope analyses by Cameca 1280.

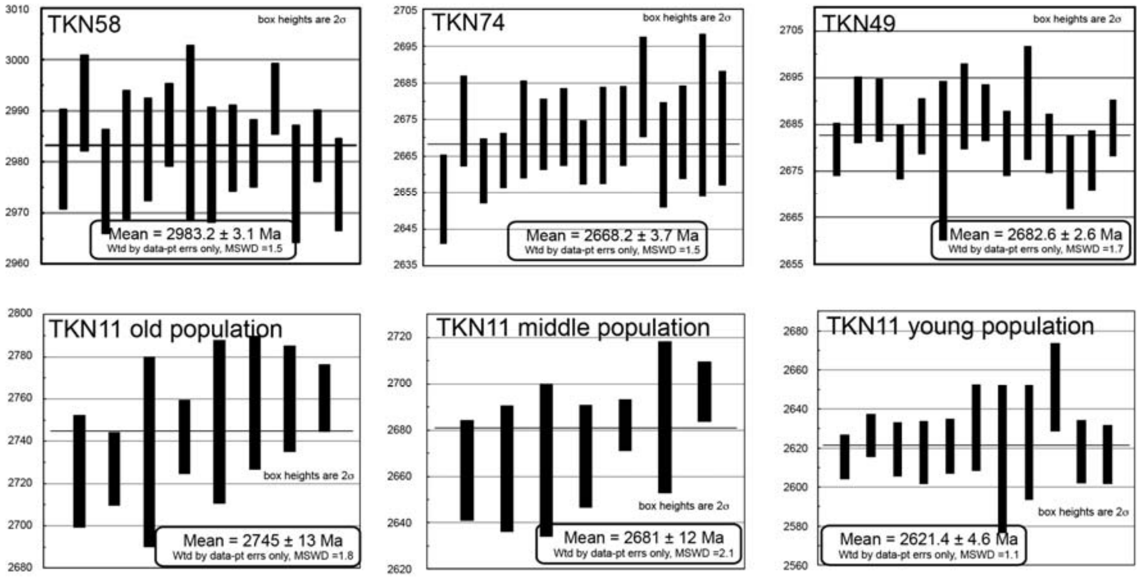


Figure DR5: Weighted mean histograms of the $^{207}Pb/^{206}Pb$ ages of the studied samples. Y-axis is in million years.

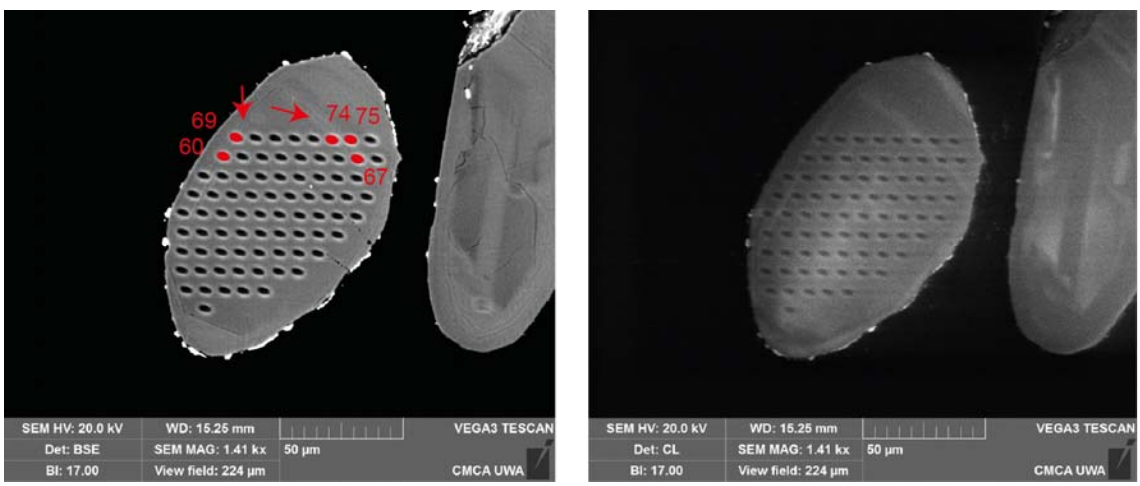


Figure DR6: SEM and BSE images of zircon TKN58_13. Arrows point to potential micro-cracks. The numbered filled ellipses refer to the analyses in Table DR5 and show elevated $OH/^{16}O$ ratios. All other spots show a uniform $OH/^{16}O$ signature (Table DR5)

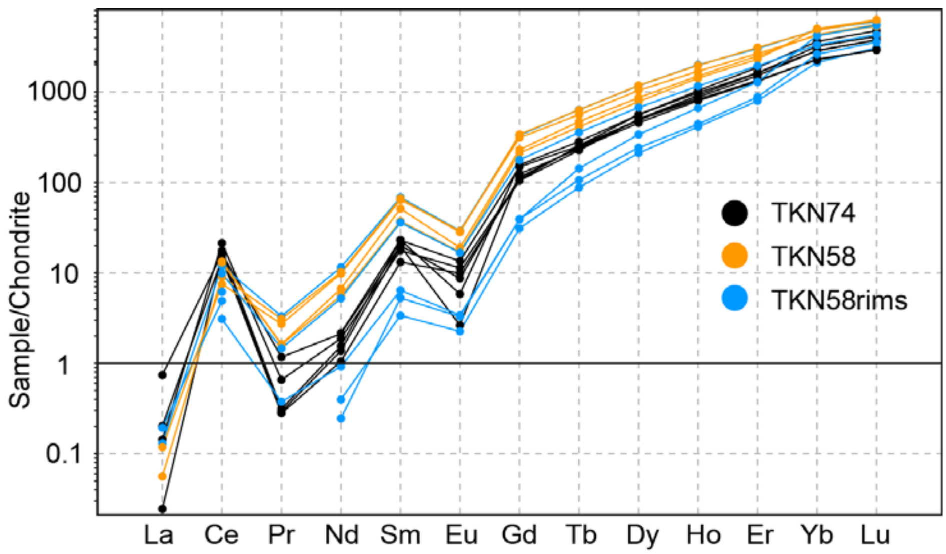


Figure DR7: Chondrite-normalized REE of TKN74 and TKN58 zircons (see also table DR6). Chondrite values for normalization are from McDonough and Sun (1995).

Table DR1: Whole rock analyses for major and trace elements.

						Standard	Reference*	Standard	Reference
ELEMENTS	***UNITS***	**TKN49**	**TKN11**	**TKN74**	**TKN58**	**BB1**	**BB1**	**KG1**	**KG1**
SiO2	%	52.09	49.17	73.86	75.29	52.23	51.82	71.21	71.37
TiO2	%	0.58	0.87	0.22	0.35	2.06	2.02	0.23	0.24
Al2O3	%	5.51	9.9	9.96	10.99	15.43	15.33	15.02	14.95
Fe2O3	%	12.1	16.35	6.99	4.97	12.26	12.22	20.8	20.8
FeO	%	9.49	12.67	5.31	4.04	7.89	7.99	1.37	
MnO	%	0.21	2.55	0.05	0.03	0.16	0.16	0.04	0.04
MgO	%	19.93	4.89	7.25	5.18	4.63	4.72	0.47	0.48
CaO	%	9.07	13.87	0.08	0.09	8.7	8.71	2.11	2.16
Na2O	%	0.39	1.63	0.26	0.18	3.12	3.03	4.18	4.07
K2O	%	0.12	0.54	0.84	1.15	0.45	0.46	3.45	3.47
P2O5	%	0.061	0.086	0.008	0.037	0.252	0.25	0.065	0.08
SO3	%	0.027	0.02	0.013	0.019	0.16	0.16	0.01	0.03
Sc	ppm	15	31	b.d.	b.d.	25	27.7	b.d.	2.4
V	ppm	123	213	b.d.	b.d.	238		15	14.6
Cr	ppm	1454	619	b.d.	b.d.	144	150	163	170
Co	ppm	85.8	77	24.7	27.4	34.8	37	3.3	
Ni	ppm	908.7	204.8	b.d.	b.d.	42.6	41	3.9	8
Cu	ppm	155.4	2.8	b.d.	b.d.	75.6	82	4.7	6.2
Zn	ppm	71	48	30	40	115	116	45	41
Ga	ppm	8.4	13.1	21.5	24.2	24.9	23	19.9	20
Li	ppm	4.1	4	35.8	89.9	8.3	7.6	30.5	
Cs	ppm	0.1		0.6	1.3	0.4		2.4	2.2
Rb	ppm	1.2	15.8	34.4	60.4	11.6	12.4	97.9	96
Sr	ppm	8	46.6	5.9	11.2	243.5	245	548.2	515
Ba	ppm	12.4	444.4	215.9	345.8	150.5	152	1460.2	1373
Y	ppm	10.2	23.1	37.6	152.6	36.6	39.8	4.5	4.5
Nb	ppm	4.8	2.7	11.2	43.8	6.9	7.6	9.1	9.5
Zr	ppm	53	56	418	695	141	153	214	190
La	ppm	11.5	4.4	20.1	95.3	11.4	10.95	42.1	43.8
Ce	ppm	22.5	10.3	39.2	204.2	26.3	26.8	69.3	71.3
Pr	ppm	2.7	1.5	4.8	25.6	3.6	3.63	6.4	6.6
Nd	ppm	11	8.3	22	108.5	17.8	18.75	20.5	22.4
Sm	ppm	2.2	2.3	4.5	23.9	5.9	5.69	2.7	2.8
Eu	ppm	0.7	1.1	1.7	1.3	2	2.01	0.8	0.8
Gd	ppm	2.5	4	6	25.1	6.4	7.26	1.7	1.5
Dy	ppm	1.8	4.1	6	26.5	7	7.27	1	0.8
Ho	ppm	0.4	0.9	1.5	5.9	1.4	1.46	0.2	0.1
Er	ppm	1	2.2	5.2	17.8	3.4	3.95	0.3	0.4
Tb	ppm	0.4	0.8	0.9	4.2	1.1	1.22	0.2	0.2
Tm	ppm	0.2	0.3	0.9	2.9	0.5	0.53	b.d.	
Yb	ppm	0.9	1.9	6.4	18.2	3.5	3.32	0.5	0.5
Lu	ppm	0.1	0.3	1.1	2.7	0.5	0.49	b.d.	0.1
Hf	ppm	1.6	1.5	12.5	22.5	4.2	4	5.3	5
Ta	ppm	0.5	0.4	0.6	2.5	0.6	0.5	1	1
Pb	ppm	2.1	5.2	2.5	11	4.8	4.4	36	40
Th	ppm	3.9	0.3	7.3	39.3	1.6	1.8	15.9	17.4
U	ppm	1.1	0.2	1.1	6.7	0.3	0.3	3.9	4.2

***Morris (2007)**

Table DR2: Compilation of U-Pb SHRIMP II analyses and oxygen isotope analyses (SIMS; Cameca 1280)

Spot Name	ppm U	ppm Th	232Th /238U	4-corr %com 206	4corr 206* /238	% err	4corr 207* /206*	% err	% Dis-cor-dant	r 206Pb /238U Age	1s err	204corr 207Pb /206Pb Age	1s err	RAW DATA from CIPS		Drift corrected		SIMS corrected ratios		FINAL Delta values	
														18O/16O	σ int (rel.%)	18O/16O	σ abs	18/16O	σ abs	$\delta^{18}O$	2σ abs
TKN58-01	444	267	0.622	b.d*	0.5822	1.4	0.2200	0.30	+1	2958	34	**2980**	**5**	0.0020101	0.016	0.0020101	0.0000003	0.0020133	0.0000005	**4.1**	**0.5**
TKN58-02	479	330	0.711	b.d	0.5881	1.4	0.2215	0.29	+0	2982	34	**2991**	**5**	0.0020088	0.013	0.0020088	0.0000003	0.0020120	0.0000005	**3.4**	**0.5**
														0.0020099	0.014	0.0020099	0.0000003	0.0020131	0.0000005	**3.9**	**0.5**
TKN58-05	857	95	0.114	0.025	0.6095	1.4	0.2152	0.20	-5	3068	34	**2945**	**3**	0.0020094	0.009	0.0020094	0.0000002	0.0020126	0.0000004	**3.7**	**0.4**
TKN58-06	444	281	0.654	0.046	0.5864	1.5	0.2194	0.31	+0	2975	35	**2976**	**5**	0.0020090	0.009	0.0020090	0.0000002	0.0020122	0.0000004	**3.5**	**0.4**
TKN58-07	280	163	0.603	0.022	0.5971	1.5	0.2201	0.39	-2	3018	37	**2981**	**6**	0.0020084	0.008	0.0020084	0.0000002	0.0020115	0.0000004	**3.2**	**0.4**
TKN58-08	570	241	0.437	0.017	0.5824	1.4	0.2159	0.27	-0	2958	34	**2950**	**4**	0.0020089	0.013	0.0020089	0.0000003	0.0020121	0.0000005	**3.4**	**0.5**
TKN58-09	413	272	0.680	b.d	0.5796	1.5	0.2181	0.31	+1	2947	35	**2967**	**5**	0.0020074	0.013	0.0020074	0.0000003	0.0020106	0.0000005	**2.7**	**0.5**
TKN58-10	772	475	0.636	b.d	0.5532	1.7	0.2172	0.35	+5	2839	39	**2960**	**6**	0.0020088	0.009	0.0020088	0.0000002	0.0020120	0.0000004	**3.4**	**0.4**
TKN58-11	295	145	0.506	0.005	0.5755	1.8	0.2202	0.31	+2	2930	42	**2982**	**5**	0.0020088	0.011	0.0020088	0.0000002	0.0020120	0.0000005	**3.4**	**0.5**
TKN58-12	472	278	0.607	0.000	0.5760	1.7	0.2209	0.25	+2	2932	41	**2987**	**4**	0.0020080	0.012	0.0020080	0.0000002	0.0020112	0.0000005	**3.0**	**0.5**
TKN58-13	518	394	0.786	0.019	0.5750	1.7	0.2207	0.53	+2	2928	41	**2986**	**9**	0.0020090	0.019	0.0020090	0.0000004	0.0020122	0.0000006	**3.5**	**0.6**
TKN58-14	247	143	0.598	0.034	0.5780	1.8	0.2198	0.35	+2	2941	42	**2979**	**6**	0.0020089	0.016	0.0020089	0.0000003	0.0020121	0.0000005	**3.4**	**0.5**
TKN58-15	480	337	0.724	0.022	0.5729	1.7	0.2203	0.26	+3	2920	41	**2983**	**4**	0.0020093	0.011	0.0020093	0.0000002	0.0020125	0.0000005	**3.6**	**0.5**
TKN58-16	824	89	0.111	0.000	0.5633	1.7	0.2105	0.19	+1	2880	39	**2910**	**3**	0.0020014	0.020	0.0020014	0.0000004	0.0020045	0.0000006	**-0.3**	**0.6**
TKN58-17	1037	10	0.010	0.006	0.5610	1.7	0.2031	0.36	-1	2871	39	**2852**	**6**	0.0020018	0.015	0.0020018	0.0000003	0.0020050	0.0000005	**-0.1**	**0.5**
TKN58-18	454	168	0.382	0.000	0.5600	1.7	0.2177	0.28	+4	2867	40	**2964**	**4**	0.0020093	0.011	0.0020093	0.0000002	0.0020125	0.0000005	**3.6**	**0.5**
TKN58-19	805	19	0.024	b.d	0.5565	2.5	0.2066	0.20	+1	2852	57	**2879**	**3**	0.0020010	0.014	0.0020010	0.0000003	0.0020042	0.0000005	**-0.5**	**0.5**
TKN58A-1	805	168	0.215	0.016	0.5481	1.7	0.2049	0.20	+2	2817	39	**2865**	**3**	0.0020064	0.012	0.0020064	0.0000002	0.0020103	0.0000005	**2.5**	**0.5**
TKN58A-2c	663	420	0.654	b.d	0.5914	1.7	0.2201	0.20	-1	2995	41	**2982**	**3**	0.0020088	0.014	0.0020088	0.0000003	0.0020126	0.0000005	**3.7**	**0.5**
TKN58A-2r	783	704	0.929	0.006	0.5740	1.7	0.2186	0.28	+2	2924	40	**2970**	**5**	0.0020060	0.009	0.0020060	0.0000002	0.0020098	0.0000005	**2.3**	**0.5**
TKN58A-3	595	403	0.700	0.003	0.5820	1.7	0.2216	0.21	+1	2957	41	**2992**	**3**	0.0020088	0.008	0.0020088	0.0000002	0.0020127	0.0000005	**3.7**	**0.5**
TKN58A-4	625	190	0.314	0.015	0.5606	1.7	0.2087	0.87	+1	2869	40	**2895**	**14**								
TKN58A-5	814	300	0.380	0.000	0.5573	1.7	0.2052	0.19	+1	2855	39	**2868**	**3**	0.0020064	0.014	0.0020064	0.0000003	0.0020102	0.0000005	**2.5**	**0.5**
TKN58A-6	1035	11	0.011	0.007	0.5472	1.7	0.1985	0.17	+0	2813	39	**2814**	**3**	0.0020016	0.013	0.0020017	0.0000003	0.0020055	0.0000005	**0.1**	**0.5**
TKN58A-7	655	394	0.622	0.005	0.5844	1.7	0.2181	0.21	-0	2967	41	**2967**	**3**	0.0020081	0.013	0.0020081	0.0000003	0.0020119	0.0000005	**3.4**	**0.5**
TKN58A-8	1412	34	0.025	0.008	0.5043	1.7	0.1865	0.16	+4	2632	36	**2711**	**3**	0.0020023	0.010	0.0020023	0.0000002	0.0020061	0.0000005	**0.4**	**0.5**
TKN58A-9	1175	19	0.017	0.003	0.5449	1.7	0.1972	0.16	-0	2804	39	**2803**	**3**	0.0020025	0.013	0.0020025	0.0000003	0.0020063	0.0000005	**0.5**	**0.5**
TKN58A-9C	707	263	0.385	0.005	0.5653	1.7	0.2075	0.20	-0	2888	40	**2886**	**3**	0.0020086	0.013	0.0020086	0.0000003	0.0020124	0.0000005	**3.6**	**0.5**
TKN58A-10	614	420	0.707	0.000	0.5854	1.7	0.2193	0.35	+0	2971	41	**2976**	**6**	0.0020088	0.018	0.0020088	0.0000004	0.0020127	0.0000006	**3.7**	**0.6**
TKN58A-11	947	122	0.134	0.000	0.5573	1.7	0.2057	0.44	+1	2855	39	**2872**	**7**	0.0020080	0.013	0.0020080	0.0000003	0.0020118	0.0000005	**3.3**	**0.5**
TKN58A-12C	592	398	0.695	0.005	0.5867	1.7	0.2203	0.21	+0	2976	41	**2983**	**3**	0.0020088	0.017	0.0020088	0.0000003	0.0020126	0.0000006	**3.7**	**0.6**
TKN58A-12R	905	160	0.183	0.025	0.5270	1.7	0.1962	0.19	+3	2729	38	**2795**	**3**	0.0020023	0.014	0.0020023	0.0000003	0.0020061	0.0000005	**0.5**	**0.5**
TKN58A-13C	372	238	0.661	b.d	0.5857	1.8	0.2193	0.28	+0	2972	42	**2975**	**4**	0.0020084	0.013	0.0020084	0.0000003	0.0020123	0.0000005	**3.5**	**0.5**
TKN58A-13R	594	63	0.109	0.019	0.5456	1.7	0.2037	0.40	+2	2807	39	**2856**	**6**	0.0020030	0.017	0.0020030	0.0000003	0.0020068	0.0000006	**0.8**	**0.6**
TKN58A-14R	866	11	0.013	0.006	0.5479	1.7	0.2028	0.36	+1	2817	39	**2848**	**6**	0.0020090	0.018	0.0020090	0.0000004	0.0020128	0.0000006	**3.8**	**0.6**
TKN58A-15C	889	256	0.298	b.d	0.5311	1.7	0.2012	0.31	+4	2746	38	**2836**	**5**	0.0020078	0.011	0.0020078	0.0000002	0.0020117	0.0000005	**3.2**	**0.5**
TKN58A-16R	762	305	0.413	0.014	0.5667	1.7	0.2132	0.44	+2	2894	40	**2930**	**7**								
TKN49-01	1133	393	0.358	0.000	0.4984	0.8	0.1829	0.17	+3	2607	18	**2680**	**3**	0.0020139	0.013	0.0020139	0.0000003	0.0020171	0.0000005	**5.9**	**0.5**
TKN49-02	727	232	0.329	0.004	0.5013	0.9	0.1839	0.21	+3	2620	19	**2688**	**3**	0.0020143	0.017	0.0020143	0.0000003	0.0020175	0.0000005	**6.1**	**0.5**
TKN49-03	768	304	0.409	0.002	0.5027	0.9	0.1838	0.20	+3	2626	19	**2688**	**3**	0.0020138	0.016	0.0020138	0.0000003	0.0020170	0.0000005	**5.9**	**0.5**
TKN49-04	1091	365	0.345	0.006	0.4969	0.8	0.1829	0.17	+4	2600	18	**2679**	**3**	0.0020147	0.013	0.0020147	0.0000003	0.0020179	0.0000005	**6.3**	**0.5**
TKN49-05	1060	371	0.362	0.005	0.5051	0.8	0.1820	0.17	+2	2636	18	**2671**	**3**	0.0020132	0.011	0.0020132	0.0000002	0.0020164	0.0000005	**5.6**	**0.5**
TKN49-06	1000	279	0.289	0.001	0.5045	0.9	0.1835	0.18	+2	2633	18	**2684**	**3**	0.0020147	0.022	0.0020147	0.0000004	0.0020179	0.0000006	**6.3**	**0.6**
TKN49-07	864	357	0.427	b.d	0.5037	0.9	0.1827	0.51	+2	2630	19	**2677**	**8**	0.0020136	0.015	0.0020136	0.0000003	0.0020168	0.0000005	**5.8**	**0.5**
TKN49-08	1234	611	0.512	b.d	0.5043	1.6	0.1839	0.28	+3	2632	36	**2689**	**5**								
TKN49-09	1088	496	0.471	0.007	0.4896	0.8	0.1820	0.17	+5	2569	18	**2671**	**3**								
TKN49-10	1097	418	0.394	0.007	0.4968	0.8	0.1838	0.18	+4	2600	18	**2687**	**3**	0.0020139	0.011	0.0020139	0.0000002	0.0020171	0.0000005	**5.9**	**0.5**
TKN49-11	745	219	0.304	0.006	0.4929	0.9	0.1831	0.21	+4	2583	19	**2681**	**3**	0.0020129	0.009	0.0020129	0.0000002	0.0020161	0.0000004	**5.4**	**0.4**
TKN49-12	645	277	0.443	0.030	0.5036	2.0	0.1840	0.36	+3	2629	42	**2689**	**6**	0.0020124	0.011	0.0020124	0.0000002	0.0020156	0.0000005	**5.2**	**0.5**
TKN49-13	924	375	0.419	0.014	0.4796	1.7	0.1788	0.38	+5	2526	35	**2642**	**6**								
TKN49-14	967	337	0.360	b.d	0.5002	2.3	0.1831	0.19	+3	2615	50	**2681**	**3**	0.0020134	0.009	0.0020134	0.0000002	0.0020165	0.0000004	**5.7**	**0.4**
TKN49-15	764	337	0.456	0.011	0.4983	2.4	0.1816	0.22	+3	2606	52	**2668**	**4**	0.0020136	0.008	0.0020136	0.0000002	0.0020168	0.0000004	**5.8**	**0.4**
TKN49-16	683	255	0.385	b.d	0.5008	1.7	0.1824	0.24	+3	2617	37	**2675**	**4**	0.0020141	0.008	0.0020141	0.0000002	0.0020173	0.0000004	**6.0**	**0.4**
TKN49-17	813	316	0.401	0.000	0.4992	1.7	0.1817	0.21	+3	2610	36	**2668**	**4**	0.0020136	0.017	0.0020136	0.0000003	0.0020168	0.0000005	**5.8**	**0.5**
TKN49-18	989	348	0.363	b.d	0.5014	1.7	0.1827	0.19	+3	2620	36	**2677**	**3**	0.0020145	0.011	0.0020145	0.0000002	0.0020177	0.0000005	**6.2**	**0.5**
TKN49-19	1248	544	0.451	0.037	0.4343	1.7	0.1685	0.19	+10	2325	33	**2543**	**3**	0.0020119	0.015	0.0020119	0.0000003	0.0020151	0.0000005	**4.9**	**0.5**
TKN49-20	1217	612	0.520	0.001	0.5013	1.7	0.1834	0.18	+3	2619	36	**2684**	**3**	0.0020140	0.011	0.0020140	0.0000002	0.0020172	0.0000005	**6.0**	**0.5**
TKN74-01	659	50	0.079	b.d	0.6179	1.7	0.2414	0.19	+1	3102	43	**3129**	**3**	0.0020073	0.015	0.0020074	0.0000003	0.0020112	0.0000005	**3.0**	**0.5**
TKN74-02	359	86	0.247	0.130	0.5090	1.8	0.1800	0.36	+0	2652	39	**2653**	**6**								
TKN74-03	265	107	0.416	0.000	0.5066	1.8	0.1824	0.37	+1	2642	40	**2674**	**6**	0.0020093	0.012	0.0020092	0.0000002	0.0020131	0.0000005	**3.9**	**0.5**
TKN74-04	481	73	0.157	0.015	0.5050	1.7	0.1809	0.26	+1	2635	38	**2661**	**4**	0.0020086	0.011	0.0020086	0.0000002	0.0020124	0.0000005	**3.6**	**0.5**
TKN74-05	775	78	0.104	b.d	0.5080	1.7	0.1812	0.22	+1	2648	37	**2664**	**4**	0.0020085	0.013	0.0020085	0.0000003	0.0020123	0.0000005	**3.5**	**0.5**
TKN74-06	514	58	0.117	0.029	0.5439	1.7	0.2052	0.57	+3	2800	40	**2868**	**9**	0.0020083	0.015	0.0020082	0.0000003	0.0020121	0.0000005	**3.4**	**0.5**
TKN74-07	249	95	0.394	0.041	0.5101	1.8	0.1821	0.40	+1	2657	40	**2672**	**7**	0.0020085	0.014	0.0020085	0.0000003	0.0020123	0.0000005	**3.5**	**0.5**
TKN74-08	450	84	0.193	b.d	0.5025	1.8	0.1820	0.29	+2	2624	38	**2671**	**5**	0.0020088	0.010	0.0020088	0.0000002	0.0020126	0.0000005	**3.7**	**0.5**
TKN74-09	548	39	0.074	0.016	0.5033	1.7	0.1953	0.23	+7	2628	37	**2787**	**4**								
TKN74-10	348	79	0.234	0.005	0.5130	1.8	0.1822	0.31	+0	2669	39	**2673**	**5**	0.0020082	0.013	0.0020081	0.0000003	0.0020120	0.0000005	**3.4**	**0.5**
TKN74-11	499	85	0.175	0.015	0.5114	1.7	0.1814	0.26	+0	2663	38	**2666**	**4**	0.0020089	0.011	0.0020089	0.0000002	0.0020127	0.0000005	**3.7**	**0.5**
TKN74-11b	230	106	0.476	0.000	0.5065	1.8	0.1819	0.39	+1	2642	40	**2671**	**7**								
TKN74-12	289	67	0.240	0.006	0.5080	1.8	0.1822	0.32	+1	2648	39	**2673**	**5**	0.0020088	0.016	0.0020087	0.0000003	0.0020126	0.0000005	**3.7**	**0.5**
TKN74-13	441	124	0.289	0.004	0.5178	1.7	0.1834	0.41	-0	2690	38	**2684**	**7**	0.0020086	0.013	0.0020086	0.0000003	0.0020124	0.0000005	**3.6**	**0.5**
TKN74-14	222	93	0.433	0.066	0.5101	1.8	0.1814	0.43	+0	2657	40	**2665**	**7**	0.0020090	0.013	0.0020090	0.0000003	0.0020128	0.0000005	**3.8**	**0.5**
TKN74-15	232	118	0.524	b.d	0.5154	1.8	0.1820	0.38	-0	2680	40	**2671**	**6**	0.0020086	0.015	0.0020085	0.0000003	0.0020124	0.0000005	**3.6**	**0.5**
TKN74-16	247	127	0.533	0.000	0.4990	1.8	0.1825	0.67	+3	2610	40	**2676**	**11**	0.0020091	0.011	0.0020091	0.0000002	0.0020129	0.0000005	**3.8**	**0.5**
TKN74-17	173	91	0.543	b.d	0.5087	1.9	0.1821	0.46	+1	2651	41	**2673**	**8**	0.0020089	0.009	0.0020088	0.0000002	0.0020127	0.0000005	**3.7**	**0.5**
15TKN11-01	154	39	0.264	0.018	0.5053	1.9	0.1836	0.98	+2	2636	42	**2686**	**16**	0.0020231	0.008	0.0020231	0.0000002	0.0020210	0.0000004	**7.9**	**0.4**
15TKN11-02	350	80	0.237	0.000	0.5112	1.7	0.1848	0.39	+2	2662	38	**2696**	**6**	0.0020228	0.013	0.0020228	0.0000003	0.0020207	0.0000004	**7.7**	**0.4**
15TKN11-03	121	59	0.509	0.000	0.4709	2.0	0.1687	0.72	+3	2488	42	**2545**	**12**	0.0020233	0.011	0.0020233	0.0000002	0.0020213	0.0000004	**8.0**	**0.4**
15TKN11-04	555	135	0.252	0.024	0.4927	1.7	0.1760	0.33	+2	2583	36	**2615**	**6**	0.0020217	0.011	0.0020217	0.0000002	0.0020196	0.0000004	**7.2**	**0.4**
15TKN11-05	581	157	0.280	0.010	0.5019	1.7	0.1771	0.33	+0	2622	36	**2626**	**5**	0.0020220	0.011	0.0020220	0.0000002	0.0020200	0.0000004	**7.4**	**0.4**
15TKN11-06	215	18	0.086	0.060	0.5139	1.8	0.1882	0.52	+2	2673	40	**2727**	**9**	0.0020234	0.015	0.0020234	0.0000003	0.0020213	0.0000005	**8.0**	**0.5**
15TKN11-07	163	47	0.297	0.192	0.5240	1.9	0.1961	2.91	+3	2716	43	**2794**	**48**	0.0020223	0.012	0.0020224	0.0000003	0.0020203	0.0000004	**7.5**	**0.4**
15TKN11-08	168	23	0.142	b.d	0.4985	1.9	0.1810	0.65	+3	2607	41	**2662**	**11**	0.0020233	0.011	0.0020233	0.0000002	0.0020212	0.0000004	**8.0**	**0.4**
15TKN11-09	76	20	0.274	0.186	0.5138	2.3	0.1815	0.99	-0	2673	50	**2667**	**16**	0.0020230	0.011	0.0020230	0.0000002	0.0020210	0.0000004	**7.9**	**0.4**
15TKN11-10	105	33	0.328	b.d	0.5158	2.1	0.1908	1.16	+3	2681	46	**2749**	**19**	0.0020229	0.008	0.0020229	0.0000002	0.0020208	0.0000004	**7.8**	**0.4**
15TKN11-11	350	75	0.221	0.041	0.4966	1.7	0.1811	0.81	+3	2599	37	**2663**	**13**	0.0020226	0.007	0.0020226	0.0000001	0.0020206	0.0000004	**7.7**	**0.4**
15TKN11-12	393	75	0.197	0.029	0.4936	1.7	0.1764	0.41	+2	2586	37	**2619**	**7**	0.0020224	0.008	0.0020224	0.0000002	0.0020203	0.0000004	**7.5**	**0.4**
15TKN11-13	251	27	0.110	b.d	0.5194	1.8	0.1892	1.36	+2	2697	40	**2735**	**22**	0.0020230	0.011	0.0020231	0.0000002	0.0020210	0.0000004	**7.9**	**0.4**
15TKN11-14	334	7	0.022	0.011	0.5238	1.8	0.1921	0.48	+2	2715	40	**2760**	**8**	0.0020227	0.010	0.0020228	0.0000002	0.0020207	0.0000004	**7.7**	**0.4**
15TKN11-15	431	87	0.209	0.000	0.4807	1.8	0.1762	0.47	+4	2530	37	**2618**	**8**	0.0020217	0.012	0.0020218	0.0000002	0.0020197	0.0000004	**7.2**	**0.4**
15TKN11-16	735	137	0.192	0.010	0.5082	1.7	0.1832	0.33	+2	2649	37	**2682**	**5**	0.0020216	0.013	0.0020216	0.0000003	0.0020195	0.0000004	**7.2**	**0.4**
15TKN11-17	481	91	0.196	0.023	0.4843	1.7	0.1766	0.41	+3	2546	37	**2621**	**7**	0.0020223	0.010	0.0020223	0.0000002	0.0020203	0.0000004	**7.5**	**0.4**
15TKN11-18	526	152	0.298	0.014	0.4892	1.7	0.1776	0.66	+3	2567	37	**2630**	**11**	0.0020227	0.010	0.0020227	0.0000002	0.0020206	0.0000004	**7.7**	**0.4**
15TKN11-19	318	9	0.029	0.104	0.5148	1.8	0.1900	0.52	+3	2677	40	**2742**	**9**	0.0020225	0.013	0.0020225	0.0000003	0.0020205	0.0000004	**7.6**	**0.4**
15TKN11-20	83	25	0.311	0.000	0.5207	2.5	0.1918	0.95	+2	2702	54	**2758**	**16**	0.0020230	0.008	0.0020230	0.0000002	0.0020209	0.0000004	**7.8**	**0.4**
15TKN11-21	424	76	0.185	0.116	0.4720	1.8	0.1735	0.47	+5	2492	36	**2592**	**8**	0.0020218	0.013	0.0020218	0.0000003	0.0020197	0.0000004	**7.3**	**0.4**
15TKN11-22	472	88	0.194	0.016	0.4868	1.7	0.1759	1.12	+3	2557	37	**2614**	**19**	0.0020216	0.010	0.0020217	0.0000002	0.0020196	0.0000004	**7.2**	**0.4**
15TKN11-23	386	79	0.213	0.047	0.4830	1.8	0.1768	0.87	+4	2540	37	**2623**	**14**	0.0020221	0.011	0.0020221	0.0000002	0.0020200	0.0000004	**7.4**	**0.4**
15TKN11-23B	430	92	0.221	0.127	0.4821	1.8	0.1763	0.48	+4	2537	37	**2618**	**8**	0.0020225	0.007	0.0020225	0.0000001	0.0020204	0.0000004	**7.6**	**0.4**
15TKN11-24	227	33	0.149	0.157	0.5049	2.0	0.1798	0.67	+1	2635	42	**2651**	**11**	0.0020229	0.015	0.0020229	0.0000003	0.0020209	0.0000005	**7.8**	**0.5**
15TKN11-25	417	80	0.198	0.018	0.4894	1.8	0.1761	0.44	+2	2568	37	**2617**	**7**	0.0020224	0.007	0.0020224	0.0000001	0.0020203	0.0000004	**7.5**	**0.4**
15TKN11-26	150	32	0.219	b.d	0.5242	2.1	0.1921	0.75	+2	2717	46	**2760**	**12**	0.0020233	0.015	0.0020233	0.0000003	0.0020213	0.0000005	**8.0**	**0.5**
15TKN11-27	216	32	0.153	0.073	0.4993	2.0	0.1817	0.66	+3	2611	42	**2669**	**11**	0.0020227	0.011	0.0020227	0.0000002	0.0020207	0.0000004	**7.7**	**0.4**
15TKN11-28	124	24	0.199	0.000	0.5206	2.2	0.1881	0.80	+1	2702	48	**2726**	**13**	0.0020230	0.008	0.0020230	0.0000002	0.0020210	0.0000004	**7.9**	**0.4**

**b.d = 204Pb counts in sample are below background counts*

Table DR3: Compilation of $^{207}Pb/^{206}Pb$ ages for the OGC standard and external spot to spot reproducibility.

Analytical Session	Weighted mean (Myrs)		Age error (95% conf.) (Myrs)	MSWD	External spot to spot error 1σ (%)
8/09/2015	3470.2	(n=4)	4.5	1.07	0.79
19/09/2015	3461.2	(n=8)	4.7	0.74	1.64
22/09/2015	3467.9	(n=9)	4.7	0.96	1.29
1/10/2015	3464.9	(n=16)	2.4	1.31	1.64
1/12/2015	3461.9	(n=14)	4.3	1.64	1.55

Table DR4. Oxygen isotope values of primary and secondary oxygen isotope standards. Uncertainties are 2SD. Selected primary standard for each session is shown in italic. *session with small <3μm spot sizes.

Session	**Penglai $\delta^{18}O$**	**Temora 2 $\delta^{18}O$**
1	*5.31 ± 0.39*	8.50 ± 0.50
2	*5.31 ± 0.42*	8.59 ± 0.36
3	4.95 ± 0.43	*8.20 ± 0.35*
4*	5.64 ± 1.68	*8.20 ± 0.97*

Table DR5: $\delta^{18}O$ values and $OH/^{16}O$ ratios of zircon grain 13 of sample TKN58 as well as Temora 2 and Penglai standards. The uniform $OH/^{16}O$ ratios in both the rim (in bold) and the core rule out post-crystallization alteration. Analyses on cracks (in italic) show elevated $OH/^{16}O$, which might be attributed to post-crystallization disturbance of the oxygen isotope system. $OH/^{16}O$ ratios of the standard zircons are homogeneous, as expected for pristine igneous zircons.

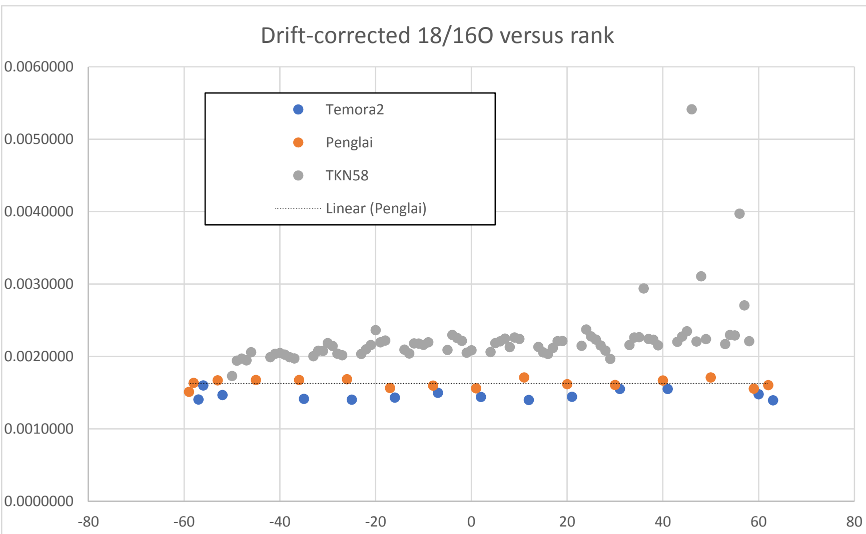
Table DR5

Analysis name	n (- to +)	Sample	RAW DATA from CIPS		Drift corrected		SIMS corrected ratios		FINAL Delta values		Raw ratios from CIPS		Drift corrected or raw ratios if no drift		BG corr*	σabs (propagated from drift correction)
			18O/16O	σ int in rel.%	18O/16O	σ abs	18O/16O	σ abs	$\delta^{18}O$	2σ abs	OH/16O	σ int rel.%	OH/16O	σ abs	OH/16O	
O_100pA-2_12TKN58_tem@01	-57	Temora2	0.0019781	0.0323451	0.0019729	0.0000006	0.0020219	0.0000012	8.3	1.2	0.0013686	1.42	0.0014043	0.000019		
O_100pA-2_12TKN58_tem@02	-56	Temora2	0.0019764	0.0353227	0.0019712	0.0000007	0.0020202	0.0000012	7.5	1.2	0.0015634	0.23	0.0015984	0.000004		
O_100pA-2_12TKN58_tem@03	-52	Temora2	0.0019777	0.0302191	0.0019729	0.0000006	0.0020220	0.0000012	8.4	1.1	0.0014334	1.01	0.0014660	0.000015		
O_100pA-2_12TKN58_tem@05	-35	Temora2	0.0019763	0.0308645	0.0019731	0.0000006	0.0020221	0.0000012	8.5	1.2	0.0013912	1.18	0.0014131	0.000016		
O_100pA-2_12TKN58_tem@06	-25	Temora2	0.0019736	0.0307498	0.0019713	0.0000006	0.0020203	0.0000012	7.5	1.2	0.0013861	1.14	0.0014018	0.000016		
O_100pA-2_12TKN58_tem@07	-16	Temora2	0.0019756	0.0311338	0.0019741	0.0000006	0.0020232	0.0000012	9.0	1.2	0.0014204	1.39	0.0014304	0.000020		
O_100pA-2_12TKN58_tem@08	-7	Temora2	0.0019742	0.0311420	0.0019735	0.0000006	0.0020226	0.0000012	8.7	1.2	0.0014925	1.30	0.0014969	0.000019		
O_100pA-2_12TKN58_tem@09	2	Temora2	0.0019729	0.0311460	0.0019731	0.0000006	0.0020221	0.0000012	8.4	1.2	0.0014408	1.28	0.0014396	0.000018		
O_100pA-2_12TKN58_tem@10	12	Temora2	0.0019714	0.0308327	0.0019725	0.0000006	0.0020216	0.0000012	8.2	1.2	0.0014055	1.07	0.0013980	0.000015		
O_100pA-2_12TKN58_tem@11	21	Temora2	0.0019693	0.0308036	0.0019713	0.0000006	0.0020203	0.0000012	7.5	1.2	0.0014540	1.28	0.0014409	0.000019		
O_100pA-2_12TKN58_tem@12	31	Temora2	0.0019704	0.0314289	0.0019733	0.0000006	0.0020224	0.0000012	8.6	1.2	0.0015704	1.54	0.0015510	0.000024		
O_100pA-2_12TKN58_tem@13	41	Temora2	0.0019676	0.0310115	0.0019714	0.0000006	0.0020205	0.0000012	7.6	1.2	0.0015753	1.10	0.0015497	0.000017		
O_100pA-2_12TKN58_tem@15	60	Temora2	0.0019678	0.0310968	0.0019733	0.0000006	0.0020224	0.0000012	8.6	1.2	0.0015148	0.89	0.0014773	0.000013		
O_100pA-2_12TKN58_tem@16	63	Temora2	0.0019665	0.0353682	0.0019723	0.0000007	0.0020213	0.0000012	8.0	1.2	0.0014338	1.29	0.0013943	0.000019		
O_100pA-2_12TKN58_PL@01	-59	Penglai	0.0019698	0.0313735	0.0019643	0.0000006	0.0020132	0.0000012	4.0	1.2	0.0014728	0.65	0.0015098	0.000010		
O_100pA-2_12TKN58_PL@02	-58	Penglai	0.0019719	0.0296904	0.0019665	0.0000006	0.0020154	0.0000011	5.1	1.1	0.0015981	0.31	0.0016344	0.000005		
O_100pA-2_12TKN58_PL@03	-53	Penglai	0.0019714	0.0301664	0.0019665	0.0000006	0.0020155	0.0000011	5.1	1.1	0.0016368	0.26	0.0016699	0.000004		
O_100pA-2_12TKN58_PL@04	-45	Penglai	0.0019714	0.0303096	0.0019672	0.0000006	0.0020161	0.0000011	5.4	1.1	0.0016463	0.38	0.0016744	0.000006		
O_100pA-2_12TKN58_PL@05	-36	Penglai	0.0019690	0.0302852	0.0019657	0.0000006	0.0020146	0.0000011	4.7	1.1	0.0016509	0.25	0.0016734	0.000004		
O_100pA-2_12TKN58_PL@06	-26	Penglai	0.0019696	0.0306204	0.0019672	0.0000006	0.0020161	0.0000012	5.4	1.1	0.0016687	0.32	0.0016850	0.000005		
O_100pA-2_12TKN58_PL@07	-17	Penglai	0.0019683	0.0313531	0.0019668	0.0000006	0.0020157	0.0000012	5.2	1.2	0.0015527	0.52	0.0015633	0.000008		
O_100pA-2_12TKN58_PL@08	-8	Penglai	0.0019694	0.0341052	0.0019687	0.0000007	0.0020177	0.0000012	6.2	1.2	0.0015919	0.94	0.0015969	0.000015		
O_100pA-2_12TKN58_PL@09	1	Penglai	0.0019696	0.0321982	0.0019697	0.0000006	0.0020187	0.0000012	6.7	1.2	0.0015586	0.88	0.0015579	0.000014		
O_100pA-2_12TKN58_PL@10	11	Penglai	0.0019644	0.0309609	0.0019655	0.0000006	0.0020143	0.0000012	4.6	1.2	0.0017155	0.08	0.0017086	0.000001		
O_100pA-2_12TKN58_PL@11	20	Penglai	0.0019676	0.0321105	0.0019694	0.0000006	0.0020184	0.0000012	6.6	1.2	0.0016298	0.76	0.0016172	0.000012		
O_100pA-2_12TKN58_PL@12	30	Penglai	0.0019665	0.0323616	0.0019693	0.0000006	0.0020183	0.0000012	6.5	1.2	0.0016233	0.81	0.0016046	0.000013		
O_100pA-2_12TKN58_PL@13	40	Penglai	0.0019655	0.0318845	0.0019692	0.0000006	0.0020181	0.0000012	6.4	1.2	0.0016911	0.74	0.0016660	0.000013		
O_100pA-2_12TKN58_PL@14	50	Penglai	0.0019622	0.0314022	0.0019668	0.0000006	0.0020158	0.0000012	5.3	1.2	0.0017400	0.37	0.0017087	0.000006		
O_100pA-2_12TKN58_PL@15	59	Penglai	0.0019642	0.0323240	0.0019696	0.0000006	0.0020186	0.0000012	6.7	1.2	0.0015909	0.59	0.0015540	0.000009		
O_100pA-2_12TKN58_PL@16	62	Penglai	0.0019632	0.0325184	0.0019690	0.0000006	0.0020179	0.0000012	6.3	1.2	0.0016414	0.67	0.0016026	0.000011		
O_100pA-2_12TKN58_13@01	-50	TKN58_1	0.0019715	0.0319069	0.0019668	0.0000006	0.0020158	0.0000012	5.3	1.2	0.0016973	1.36	0.0017286	0.000023	0.0001790	0.0000230
O_100pA-2_12TKN58_13@02	-49	TKN58_2	0.0019680	0.0343858	0.0019634	0.0000007	0.0020123	0.0000012	3.5	1.2	0.0019095	0.66	0.0019401	0.000013	0.0003905	0.0000127
O_100pA-2_12TKN58_13@03	-48	TKN58_3	0.0019686	0.0326391	0.0019642	0.0000006	0.0020131	0.0000012	3.9	1.2	0.0019395	0.57	0.0019696	0.000011	0.0004200	0.0000110
O_100pA-2_12TKN58_13@04	-47	TKN58_4	0.0019677	0.0313156	0.0019633	0.0000006	0.0020122	0.0000012	3.5	1.2	0.0019154	0.40	0.0019448	0.000008	0.0003952	0.0000078
O_100pA-2_12TKN58_13@05	-46	TKN58_5	0.0019691	0.0323004	0.0019648	0.0000006	0.0020137	0.0000012	4.2	1.2	0.0020289	0.67	0.0020577	0.000013	0.0005081	0.0000135
O_100pA-2_12TKN58_13@06	-42	TKN58_6	0.0019670	0.0313977	0.0019631	0.0000006	0.0020119	0.0000012	3.4	1.2	0.0019633	0.36	0.0019896	0.000007	0.0004399	0.0000070
O_100pA-2_12TKN58_13@07	-41	TKN58_7	0.0019666	0.0341135	0.0019628	0.0000007	0.0020117	0.0000012	3.2	1.2	0.0020103	0.27	0.0020359	0.000005	0.0004863	0.0000054
O_100pA-2_12TKN58_13@08	-40	TKN58_8	0.0019682	0.0311629	0.0019645	0.0000006	0.0020134	0.0000012	4.1	1.2	0.0020217	0.26	0.0020468	0.000005	0.0004971	0.0000052
O_100pA-2_12TKN58_13@09	-39	TKN58_9	0.0019675	0.0312840	0.0019639	0.0000006	0.0020127	0.0000012	3.7	1.2	0.0020011	0.15	0.0020255	0.000003	0.0004759	0.0000030
O_100pA-2_12TKN58_13@10	-38	TKN58_10	0.0019668	0.0310411	0.0019633	0.0000006	0.0020121	0.0000012	3.4	1.2	0.0019653	0.22	0.0019890	0.000004	0.0004394	0.0000044
O_100pA-2_12TKN58_13@11	-37	TKN58_11	0.0019689	0.0318011	0.0019655	0.0000006	0.0020144	0.0000012	4.6	1.2	0.0019475	0.42	0.0019707	0.000008	0.0004211	0.0000082
O_100pA-2_12TKN58_13@12	-33	TKN58_12	0.0019682	0.0330155	0.0019652	0.0000006	0.0020140	0.0000012	4.4	1.2	0.0019830	0.45	0.0020037	0.000009	0.0004540	0.0000089
O_100pA-2_12TKN58_13@13	-32	TKN58_13	0.0019693	0.0323101	0.0019664	0.0000006	0.0020153	0.0000012	5.0	1.2	0.0020568	0.63	0.0020769	0.000013	0.0005272	0.0000130
O_100pA-2_12TKN58_13@14	-31	TKN58_14	0.0019663	0.0331706	0.0019634	0.0000007	0.0020122	0.0000012	3.5	1.2	0.0020553	0.41	0.0020747	0.000009	0.0005251	0.0000085
O_100pA-2_12TKN58_13@15	-30	TKN58_15	0.0019686	0.0317440	0.0019658	0.0000006	0.0020147	0.0000012	4.7	1.2	0.0021653	0.36	0.0021840	0.000008	0.0006344	0.0000078

O_100pA-2_12TKN58_13@16	-29	TKN58_16	0.0019670	0.0316540	0.0019643	0.0000006	0.0020132	0.0000012	4.0	1.2	0.0021246	0.37	0.0021428	0.000008	0.0005932	0.0000078
O_100pA-2_12TKN58_13@17	-28	TKN58_17	0.0019659	0.0314799	0.0019633	0.0000006	0.0020121	0.0000012	3.5	1.2	0.0020202	0.32	0.0020377	0.000006	0.0004881	0.0000064
O_100pA-2_12TKN58_13@18	-27	TKN58_18	0.0019665	0.0317881	0.0019640	0.0000006	0.0020129	0.0000012	3.8	1.2	0.0019986	0.42	0.0020155	0.000008	0.0004659	0.0000084
O_100pA-2_12TKN58_13@19	-23	TKN58_19	0.0019667	0.0315453	0.0019646	0.0000006	0.0020134	0.0000012	4.1	1.2	0.0020184	0.24	0.0020328	0.000005	0.0004832	0.0000049
O_100pA-2_12TKN58_13@20	-22	TKN58_20	0.0019654	0.0320043	0.0019633	0.0000006	0.0020122	0.0000012	3.5	1.2	0.0020827	0.32	0.0020965	0.000007	0.0005469	0.0000067
O_100pA-2_12TKN58_13@21	-21	TKN58_21	0.0019655	0.0319848	0.0019636	0.0000006	0.0020124	0.0000012	3.6	1.2	0.0021441	0.25	0.0021572	0.000005	0.0006076	0.0000055
O_100pA-2_12TKN58_13@22	-20	TKN58_22	0.0019638	0.0315948	0.0019619	0.0000006	0.0020107	0.0000012	2.7	1.2	0.0023495	0.86	0.0023620	0.000020	0.0008124	0.0000201
O_100pA-2_12TKN58_13@23	-19	TKN58_23	0.0019635	0.0314898	0.0019617	0.0000006	0.0020105	0.0000012	2.7	1.2	0.0021836	0.22	0.0021955	0.000005	0.0006458	0.0000048
O_100pA-2_12TKN58_13@24	-18	TKN58_24	0.0019655	0.0336775	0.0019638	0.0000007	0.0020127	0.0000012	3.7	1.2	0.0022077	0.20	0.0022190	0.000005	0.0006694	0.0000045
O_100pA-2_12TKN58_13@25	-14	TKN58_25	0.0019650	0.0313651	0.0019637	0.0000006	0.0020126	0.0000012	3.7	1.2	0.0020835	0.30	0.0020922	0.000006	0.0005426	0.0000063
O_100pA-2_12TKN58_13@26	-13	TKN58_26	0.0019656	0.0327381	0.0019644	0.0000006	0.0020133	0.0000012	4.0	1.2	0.0020310	0.37	0.0020392	0.000008	0.0004896	0.0000076
O_100pA-2_12TKN58_13@27	-12	TKN58_27	0.0019646	0.0314882	0.0019635	0.0000006	0.0020123	0.0000012	3.5	1.2	0.0021709	0.14	0.0021784	0.000003	0.0006288	0.0000030
O_100pA-2_12TKN58_13@28	-11	TKN58_28	0.0019645	0.0317121	0.0019635	0.0000006	0.0020123	0.0000012	3.5	1.2	0.0021701	0.06	0.0021770	0.000001	0.0006273	0.0000014
O_100pA-2_12TKN58_13@29	-10	TKN58_29	0.0019647	0.0319156	0.0019638	0.0000006	0.0020126	0.0000012	3.7	1.2	0.0021536	0.20	0.0021599	0.000004	0.0006102	0.0000043
O_100pA-2_12TKN58_13@30	-9	TKN58_30	0.0019661	0.0323261	0.0019653	0.0000006	0.0020142	0.0000012	4.5	1.2	0.0021884	0.27	0.0021941	0.000006	0.0006444	0.0000060
O_100pA-2_12TKN58_13@31	**-5**	**TKN58_31**	**0.0019580**	**0.0346555**	**0.0019576**	**0.0000007**	**0.0020062**	**0.0000012**	**0.5**	**1.2**	**0.0020860**	**0.36**	**0.0020891**	**0.000007**	**0.0005395**	**0.0000075**
O_100pA-2_12TKN58_13@32	-4	TKN58_32	0.0019641	0.0317592	0.0019637	0.0000006	0.0020126	0.0000012	3.7	1.2	0.0022935	0.31	0.0022960	0.000007	0.0007464	0.0000071
O_100pA-2_12TKN58_13@33	-3	TKN58_33	0.0019652	0.0330974	0.0019649	0.0000007	0.0020137	0.0000012	4.3	1.2	0.0022516	0.20	0.0022535	0.000005	0.0007038	0.0000046
O_100pA-2_12TKN58_13@34	-2	TKN58_34	0.0019638	0.0315663	0.0019636	0.0000006	0.0020124	0.0000012	3.6	1.2	0.0022136	0.25	0.0022149	0.000005	0.0006653	0.0000055
O_100pA-2_12TKN58_13@35	-1	TKN58_35	0.0019622	0.0311794	0.0019621	0.0000006	0.0020109	0.0000012	2.8	1.2	0.0020498	0.18	0.0020504	0.000004	0.0005008	0.0000036
O_100pA-2_12TKN58_13@36	0	TKN58_36	0.0019642	0.0318187	0.0019642	0.0000006	0.0020130	0.0000012	3.9	1.2	0.0020834	0.24	0.0020834	0.000005	0.0005338	0.0000050
O_100pA-2_12TKN58_13@37	4	TKN58_37	0.0019646	0.0312555	0.0019650	0.0000006	0.0020138	0.0000012	4.3	1.2	0.0020636	0.28	0.0020610	0.000006	0.0005114	0.0000058
O_100pA-2_12TKN58_13@38	5	TKN58_38	0.0019647	0.0318755	0.0019652	0.0000006	0.0020141	0.0000012	4.4	1.2	0.0021859	0.25	0.0021828	0.000005	0.0006332	0.0000054
O_100pA-2_12TKN58_13@39	6	TKN58_39	0.0019651	0.0325219	0.0019657	0.0000006	0.0020146	0.0000012	4.7	1.2	0.0022125	0.55	0.0022088	0.000012	0.0006592	0.0000121
O_100pA-2_12TKN58_13@40	7	TKN58_40	0.0019631	0.0326615	0.0019638	0.0000006	0.0020126	0.0000012	3.7	1.2	0.0022504	0.60	0.0022460	0.000014	0.0006964	0.0000135
O_100pA-2_12TKN58_13@41	**8**	**TKN58_41**	**0.0019564**	**0.0314420**	**0.0019572**	**0.0000006**	**0.0020059**	**0.0000012**	**0.3**	**1.2**	**0.0021335**	**0.41**	**0.0021285**	**0.000009**	**0.0005789**	**0.0000089**
O_100pA-2_12TKN58_13@42	9	TKN58_42	0.0019630	0.0308654	0.0019639	0.0000006	0.0020127	0.0000012	3.7	1.1	0.0022656	0.17	0.0022599	0.000004	0.0007103	0.0000039
O_100pA-2_12TKN58_13@43	10	TKN58_43	0.0019610	0.0307987	0.0019619	0.0000006	0.0020107	0.0000012	2.8	1.1	0.0022462	0.12	0.0022400	0.000003	0.0006904	0.0000027
O_100pA-2_12TKN58_13@44	14	TKN58_44	0.0019612	0.0307447	0.0019625	0.0000006	0.0020113	0.0000011	3.0	1.1	0.0021402	0.23	0.0021314	0.000005	0.0005818	0.0000049
O_100pA-2_12TKN58_13@45	15	TKN58_45	0.0019635	0.0311882	0.0019649	0.0000006	0.0020138	0.0000012	4.3	1.2	0.0020650	0.22	0.0020557	0.000004	0.0005060	0.0000045
O_100pA-2_12TKN58_13@46	16	TKN58_46	0.0019608	0.0309680	0.0019623	0.0000006	0.0020111	0.0000012	2.9	1.1	0.0020439	0.16	0.0020339	0.000003	0.0004842	0.0000032
O_100pA-2_12TKN58_13@47	17	TKN58_47	0.0019606	0.0352242	0.0019622	0.0000007	0.0020110	0.0000012	2.9	1.2	0.0021255	0.19	0.0021149	0.000004	0.0005653	0.0000040
O_100pA-2_12TKN58_13@48	18	TKN58_48	0.0019622	0.0318398	0.0019639	0.0000006	0.0020127	0.0000012	3.8	1.2	0.0022215	0.22	0.0022102	0.000005	0.0006606	0.0000050
O_100pA-2_12TKN58_13@49	19	TKN58_49	0.0019602	0.0314265	0.0019619	0.0000006	0.0020107	0.0000012	2.8	1.2	0.0022249	0.14	0.0022130	0.000003	0.0006634	0.0000031
O_100pA-2_12TKN58_13@50	23	TKN58_50	0.0019607	0.0317836	0.0019628	0.0000006	0.0020116	0.0000012	3.2	1.2	0.0021601	0.31	0.0021457	0.000007	0.0005961	0.0000067
O_100pA-2_12TKN58_13@51	**24**	**TKN58_51**	**0.0019562**	**0.0314621**	**0.0019584**	**0.0000006**	**0.0020071**	**0.0000012**	**0.9**	**1.2**	**0.0023857**	**0.41**	**0.0023707**	**0.000010**	**0.0008211**	**0.0000097**
O_100pA-2_12TKN58_13@52	25	TKN58_52	0.0019609	0.0309566	0.0019632	0.0000006	0.0020120	0.0000012	3.4	1.1	0.0022929	0.22	0.0022773	0.000005	0.0007276	0.0000051
O_100pA-2_12TKN58_13@53	26	TKN58_53	0.0019610	0.0307238	0.0019634	0.0000006	0.0020122	0.0000011	3.5	1.1	0.0022484	0.12	0.0022321	0.000003	0.0006825	0.0000026
O_100pA-2_12TKN58_13@54	27	TKN58_54	0.0019597	0.0305676	0.0019622	0.0000006	0.0020110	0.0000011	2.9	1.1	0.0021680	0.10	0.0021511	0.000002	0.0006014	0.0000021
O_100pA-2_12TKN58_13@55	28	TKN58_55	0.0019619	0.0312493	0.0019645	0.0000006	0.0020134	0.0000012	4.1	1.2	0.0020976	0.37	0.0020801	0.000008	0.0005304	0.0000078
O_100pA-2_12TKN58_13@56	29	TKN58_56	0.0019607	0.0307109	0.0019634	0.0000006	0.0020122	0.0000011	3.5	1.1	0.0019829	0.16	0.0019647	0.000003	0.0004151	0.0000031
O_100pA-2_12TKN58_13@57	33	TKN58_57	0.0019611	0.0313402	0.0019641	0.0000006	0.0020130	0.0000012	3.9	1.2	0.0021766	0.22	0.0021560	0.000005	0.0006064	0.0000048
O_100pA-2_12TKN58_13@58	34	TKN58_58	0.0019606	0.0321508	0.0019637	0.0000006	0.0020126	0.0000012	3.7	1.2	0.0022819	0.19	0.0022606	0.000004	0.0007110	0.0000043
O_100pA-2_12TKN58_13@59	35	TKN58_59	0.0019607	0.0318271	0.0019639	0.0000006	0.0020127	0.0000012	3.8	1.2	0.0022866	0.15	0.0022647	0.000003	0.0007151	0.0000035
O_100pA-2_12TKN58_13@60	**36**	***TKN58_60***	***0.0019546***	***0.0356869***	***0.0019579***	***0.0000007***	***0.0020066***	***0.0000012***	***0.7***	***1.2***	***0.0029607***	***0.11***	***0.0029382***	***0.000003***	***0.0013886***	***0.0000032***
O_100pA-2_12TKN58_13@61	37	TKN58_61	0.0019608	0.0305820	0.0019642	0.0000006	0.0020131	0.0000011	3.9	1.1	0.0022632	0.12	0.0022400	0.000003	0.0006904	0.0000028
O_100pA-2_12TKN58_13@62	38	TKN58_62	0.0019590	0.0306592	0.0019625	0.0000006	0.0020113	0.0000011	3.0	1.1	0.0022530	0.13	0.0022292	0.000003	0.0006796	0.0000029
O_100pA-2_12TKN58_13@63	39	TKN58_63	0.0019591	0.0305935	0.0019627	0.0000006	0.0020115	0.0000011	3.2	1.1	0.0021765	0.08	0.0021521	0.000002	0.0006025	0.0000018
O_100pA-2_12TKN58_13@64	43	TKN58_64	0.0019582	0.0305638	0.0019622	0.0000006	0.0020110	0.0000011	2.9	1.1	0.0022287	0.11	0.0022018	0.000003	0.0006522	0.0000026

O_100pA-2_12TKN58_13@65	44	TKN58_65	0.0019577	0.0321833	0.0019618	0.0000006	0.0020106	0.0000012	2.7	1.2	0.0023021	0.16	0.0022746	0.000004	0.0007250	0.0000038
O_100pA-2_12TKN58_13@66	45	TKN58_66	0.0019576	0.0313102	0.0019618	0.0000006	0.0020106	0.0000012	2.7	1.2	0.0023750	0.06	0.0023469	0.000002	0.0007972	0.0000016
O_100pA-2_12TKN58_13@67	46	*TKN58_67*	*0.0019584*	*0.0324539*	*0.0019626*	*0.0000006*	*0.0020114*	*0.0000012*	*3.1*	*1.2*	*0.0054422*	*0.17*	*0.0054135*	*0.000009*	*0.0038638*	*0.0000093*
O_100pA-2_12TKN58_13@68	**47**	**TKN58_68**	**0.0019507**	**0.0316412**	**0.0019550**	**0.0000006**	**0.0020037**	**0.0000012**	**-0.8**	**1.2**	**0.0022358**	**0.05**	**0.0022064**	**0.000001**	**0.0006568**	**0.0000012**
O_100pA-2_12TKN58_13@69	*48*	*TKN58_69*	*0.0019553*	*0.0302088*	*0.0019597*	*0.0000006*	*0.0020084*	*0.0000011*	*1.6*	*1.1*	*0.0031360*	*0.28*	*0.0031060*	*0.000009*	*0.0015564*	*0.0000088*
O_100pA-2_12TKN58_13@70	49	TKN58_70	0.0019584	0.0302892	0.0019629	0.0000006	0.0020117	0.0000011	3.3	1.1	0.0022701	0.06	0.0022394	0.000001	0.0006898	0.0000013
O_100pA-2_12TKN58_13@71	53	TKN58_71	0.0019584	0.0302776	0.0019633	0.0000006	0.0020121	0.0000011	3.5	1.1	0.0022034	0.09	0.0021703	0.000002	0.0006206	0.0000021
O_100pA-2_12TKN58_13@72	54	TKN58_72	0.0019572	0.0305334	0.0019622	0.0000006	0.0020110	0.0000011	2.9	1.1	0.0023307	0.06	0.0022969	0.000001	0.0007473	0.0000015
O_100pA-2_12TKN58_13@73	55	TKN58_73	0.0019573	0.0307898	0.0019623	0.0000006	0.0020111	0.0000011	3.0	1.1	0.0023246	0.17	0.0022902	0.000004	0.0007406	0.0000040
O_100pA-2_12TKN58_13@74	56	*TKN58_74*	*0.0019579*	*0.0311550*	*0.0019631*	*0.0000006*	*0.0020119*	*0.0000012*	*3.3*	*1.2*	*0.0040057*	*1.05*	*0.0039706*	*0.000042*	*0.0024210*	*0.0000420*
O_100pA-2_12TKN58_13@75	*57*	***TKN58_75***	***0.0019521***	***0.0313223***	***0.0019574***	***0.0000006***	***0.0020061***	***0.0000012***	***0.4***	***1.1***	***0.0027392***	***0.26***	***0.0027035***	***0.000007***	***0.0011539***	***0.0000071***
O_100pA-2_12TKN58_13@76	**58**	**TKN58_76**	**0.0019501**	**0.0317618**	**0.0019555**	**0.0000006**	**0.0020041**	**0.0000012**	**-0.5**	**1.2**	**0.0022466**	**0.08**	**0.0022103**	**0.000002**	**0.0006607**	**0.0000018**

BG corr*= average OH/O of Temora2 and Penglai (0.001549617) subtracted from drift corrected ratios of unknown



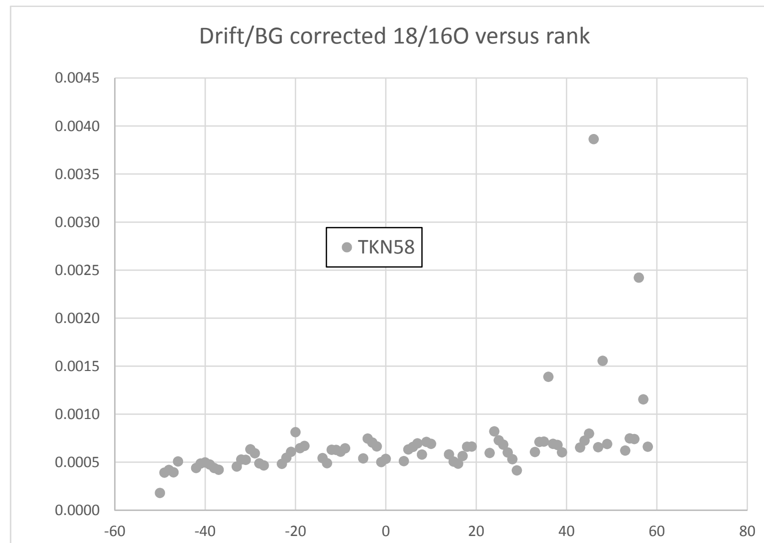


Table DR6: Trace elements concentrations in ppm of zircons from sample TKN74, TKN58, and secondary reference material NIST612.

Sample	TKN74	TKN74	TKN74	TKN74	TKN74	TKN74	TKN58A	TKN58A	TKN58A	TKN58A	TKN58A	TKN58	TKN58	TKN58	TKN58	*NIST612*	*2 σ*
Grain	17	9	10	11	12	14	6	9	12r	13c	13r	14	16	19	9	*(n=8)*	
Element (ppm)																	
Y	1314.00	1386.00	1510.00	1609.00	1730.00	1457.00	2610.00	1032.00	742.00	2240.00	3510.00	3285.00	1960.00	693.00	2792.00	*39.18*	*0.86*
La	0.01	b.d.	0.05	b.d.	0.03	0.18	b.d.	b.d.	b.d.	b.d.	0.03	0.01	b.d.	0.05	0.03	*36.55*	*0.83*
Ce	9.52	10.77	8.80	9.99	13.10	10.00	8.20	3.78	1.89	8.00	7.33	5.58	6.06	3.01	4.61	*38.83*	*0.82*
Pr	0.03	0.03	0.03	b.d.	0.06	0.11	0.15	b.d.	0.04	0.15	0.31	0.29	0.14	b.d.	0.25	*38.07*	*0.93*
Nd	0.63	0.71	0.48	0.99	0.86	0.97	3.06	0.11	0.42	2.56	5.28	4.66	2.39	0.18	4.49	*35.76*	*0.92*
Sm	2.93	3.39	1.95	3.43	2.62	2.96	7.60	0.78	0.95	5.52	10.10	9.84	5.35	0.50	9.52	*38.25*	*0.59*
Eu	0.15	0.76	0.56	0.33	0.64	0.49	1.07	0.19	0.19	0.96	1.65	1.59	0.94	0.13	1.64	*35.93*	*0.85*
Gd	24.70	29.60	20.90	31.10	21.40	22.70	45.90	7.80	7.80	42.20	66.20	67.60	35.20	6.20	62.20	*38.80*	*0.83*
Tb	8.49	9.14	8.20	10.25	9.20	8.80	17.00	5.17	3.86	14.90	23.00	22.91	12.90	3.18	20.28	*37.50*	*0.66*
Dy	112.30	121.10	123.00	137.80	138.00	120.00	213.00	83.50	59.70	193.00	289.00	291.00	166.00	52.00	256.40	*36.60*	*0.89*
Ho	43.80	45.40	50.50	53.70	56.60	47.80	82.00	36.30	24.10	77.60	109.00	107.60	63.60	22.50	92.50	*38.54*	*0.58*
Er	210.00	215.30	259.00	261.00	299.00	242.00	402.00	207.00	141.00	371.00	485.00	498.00	312.00	128.00	428.00	*39.36*	*1.01*
Tm	40.60	40.90	55.80	51.60	62.50	49.90	79.00	57.80	35.70	83.20	93.30	93.30	60.20	31.50	79.50	*37.54*	*0.88*
Yb	372.00	367.00	517.00	460.00	583.00	465.00	695.00	674.00	423.00	806.00	785.00	774.00	535.00	342.00	681.00	*39.40*	*0.41*
Lu	71.80	72.40	101.00	93.10	116.80	91.90	137.20	134.70	87.60	155.00	147.20	151.00	106.00	76.10	131.50	*37.12*	*0.55*

b.d.=below detection

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