Nu TIMS

High-precision U-Pb geochronology on Nu TIMS

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Introduction

U-Pb geochronology by Isotope Dilution Thermal Ionization Mass Spectrometry (ID-TIMS) is the gold standard for determining precise and accurate dates and rates of geological events throughout Earth's history (Hanchar and Hoskin, 2003; Bowring et al., 2006; Schoene and Baxter, 2017). The abundance of high-U minerals in most rock types and the resistance of many of these minerals to chemical and physical weathering contribute to the popularity and prolificacy of the U-Pb system. This application note will present the Nu TIMS's capability for measuring the U-Pb system when using a Daly peak jumping routine.

Instrumental set up

The PCIGR Nu TIMS instrument, equipped with 16 Faraday collectors and a single ion counting Daly photomultiplier (Table 1) with Zoom Optics, allows perfect peak alignment of Pb and U isotopes for each magnet position. For low-level Pb and U samples, electronically switchable amplifiers, including 10^{11}-ohm resistors for large ion beams (high 208 monazite samples), and 10^{12}-ohm resistors, are utilised for optimised signal-to-noise ratios on small ion beam measurements. The electronically switchable pre-amp bin allows for the greatest flexibility in analyzing a wide dynamic range of sample sizes (can be a mixture of 10^{11} and 10^{12}) with minimal downtime (<1 min).

Table 1: Detector configuration for the measurements of single detector, ion counting peak-jumping Pb, dynamic Faraday Pb and static Faraday U isotopes. (H9-L6 = Faraday collectors relative to axial position, PMO = Daly Photomultiplier, SEM = Secondary Electron Multiplier)

H9	H8	H7	H6	H5	H4	H3	H2	H1	AX	L1	L2	L3	L4	PMO	L5	SEM	L6
														204			
														205			
														206			
														207			
														208			
										208	207	206	205	204			
											208	207	206	205	204		
						270 (UO2)			267 (UO2)		265 (UO2)						

Method

A single filament arrangement using zone-refined rhenium ribbon was used. The filaments had been degassed at least one week prior to loading of the sample or standard to reduce the amount of sample spreading while loading onto filaments. Filaments are degassed at increasing 1.0 A intervals up to a maximum current of 4.0 A and held for 30 minutes. A mixture of standard SRM-982, synthetic U-Pb standards (ET100, ET500, ET2000) provided by the EARTHTIME community (Condon et al., 2015; McLean et al., 2015), and zircon Plesovice were loaded over multiple turrets. Pb and U were loaded on a single Re filament in 5 µL of a silica gel/phosphoric acid mixture (Gerstenberger and Haase, 1997). The amount of Pb loaded varied from 50-500 pg of Pb with average loading blanks of 0.3 pg. The amount of U loaded varied from 100-15000 pg of U with average loading blanks of 0.013 pg.

Daly Detector

Lead isotopes were measured by peak jumping all isotopes on the Daly detector for 100 to 160 cycles, equating to 1.5 hours of analytical time. Deadtime for the Daly was determined by measuring repeat analyses of NBS-982 at a range of intensity from 50 kcps to 1 mcps on mass ^{208}Pb at increments increasing at 50 kpcs. Each analysis measures 100 ratios at each increment, giving a deadtime of 37.40 ± 0.18 ns for Pb (Figure 1).

Mass fractionation was determined using repeat measurements of Pb standard SRM-982 with equal atoms ^{208}Pb and ^{206}Pb. Calculated mass fractionation used in these experiments was 0.27 ± 0.03‰ amu^{-1} (1σ) for the analytical sessions reported here (Supplementary Table 1). Transitory isobaric interferences due to high-molecular-weight organics, particularly on ^{204}Pb and ^{207}Pb, disappeared within approximately 60 cycles, while ionisation efficiency averaged 10^4 cps/pg of each Pb isotope. Linearity (to cps) and the associated deadtime correction of the Daly detector were monitored by repeated analyses of SRM-982 in Figure 1.

Faraday Collectors

Uranium was analysed as UO ions in static Faraday mode on 10^{12}-ohm resistors for 400 cycles and corrected for isobaric interference of ^{233}U^{18}O^{16}O on ^{235}U^{16}O^{16}O with an ^{18}O/^{16}O ratio of 0.00206. Ionisation efficiency averaged 20 mV/ng of each U isotope. U mass fractionation was corrected using the tracer solution's known ^{233}U/^{235}U ratio.

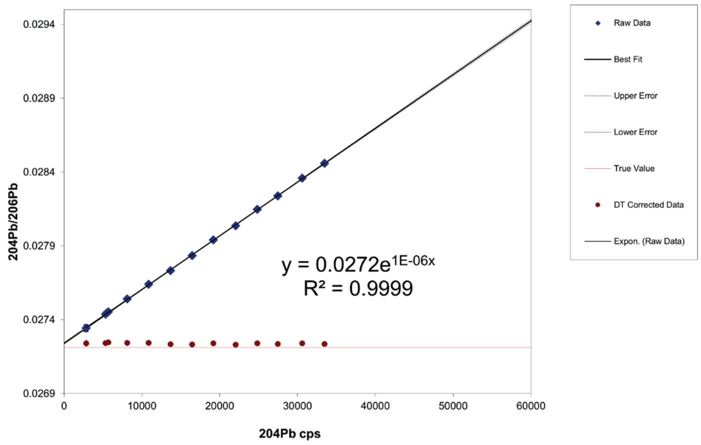

Figure 1: Daly detector deadtime characterization based on SRM-982 analyses, showing linearity (from 10 to 2 mcps). The error envelopes are barely visible in this plot as they overlap with the best fit line.

Results and Discussion

U-Pb dates and uncertainties were calculated using the algorithms of Schmitz and Schoene (2007); calibration of ET535 tracer solution (Condon et al., 2015) of $^{235}U/^{205}Pb$ = 100.233, $^{233}U/^{205}Pb$ = 0.99506, and $^{205}Pb/^{204}Pb$ = 11268; U decay constants recommended by Jaffey et al. (1971); and of $^{238}U/^{235}U$ = 137.818 (Hiess et al., 2012). The $^{206}Pb/^{238}U$ ratios for natural zircon reference samples (e.g., AN2) and dates were corrected for initial ^{230}Th disequilibrium using $D_{Th/U}$ = 0.20 ± 0.05 (1σ) and the algorithms of Crowley et al. (2007), increasing the $^{206}Pb/^{238}U$ dates of ~0.09 Ma. All common Pb in analyses was attributed to laboratory blank and subtracted based on the measured laboratory Pb isotopic composition and associated uncertainty. U blanks are estimated at 0.013 pg.

Weighted mean $^{206}Pb/^{238}U$ dates are calculated from equivalent dates (probability of fit >0.05) using Isoplot 3.0 (Ludwig, 2003). Errors on weighted mean dates are given as ±x/y/z, where x is the internal error based on analytical uncertainties only, including counting statistics, subtraction of tracer solution, and blank and initial common Pb subtraction; y includes the tracer calibration uncertainty; and z includes the ^{238}U decay constant uncertainty both propagated in quadrature. Internal errors should be considered when comparing our dates with $^{206}Pb/^{238}U$ dates from other laboratories that used the same tracer solution or a cross-calibrated tracer solution using EARTHTIME gravimetric standards. Errors, including the uncertainty in the tracer calibration, should be considered when comparing our dates with those derived from other geochronological methods using the U-Pb decay scheme (e.g., laser ablation inductively coupled plasma mass spectrometry). Errors, including uncertainties in the tracer calibration and the ^{238}U decay constant (Jaffey et al., 1971), should be considered when comparing our dates with those derived from other decay schemes (e.g., $^{40}Ar/^{39}Ar$, ^{187}Re-^{187}Os).

Results for all reference zircon and synthetic solutions yield ages that overlap with published reference values and are summarized in Table 2. The difference in precision is related to our analyses being without a double spike and on smaller aliquots (10-100 pg vs 500 pg - 1 ng). Details of the results can be found in Supplementary Table 2.

Table 2: Results of 91500, AN2, PLES535, ET100, ET500, ET2000 weighted mean age, mean squared weighted deviation (MSWD) and reference age.

Sample	Weighted mean age, MSWD and reference age
91500	Weighted mean $^{206}Pb/^{238}U$ age = 1063.57 ± 0.15 Ma (2σ); MSWD = 1.20 (n=5) Reference Age = 1062.4 ± 0.4 Ma (Wiedenbeck et al., 1995)
AN2	Weighted mean $^{207}Pb/^{206}Pb$ age = 2710.60 ± 0.33 Ma (2σ); MSWD = 1.00 (n=4) Reference Age = 2710.44 ± 0.32 Ma (Wall et al., 2016)
PLES535	Weighted mean $^{206}Pb/^{238}U$ age = 337.23 ± 0.10 Ma (2σ); MSWD = 0.77 (n=5) Reference Age = 337.201 ± 0.025 Ma (Widmann et al., 2019)
ET100	Weighted mean $^{206}Pb/^{238}U$ age = 100.140 ± 0.030 Ma (2σ); MSWD = 1.28 (n=9) Reference Age = 100.173 ± 0.003 Ma (Schaltegger et al., 2021)
ET500	Weighted mean $^{206}Pb/^{238}U$ age = 500.052 ± 0.088 Ma (2σ); MSWD = 1.83 (n=15)
ET2000	Weighted mean $^{207}Pb/^{206}Pb$ age = 1999.87 ± 0.43 Ma (2σ); MSWD = 1.19 (n=14) Reference Age = 1999.935 ± 0.063 Ma (Schaltegger et al., 2021)

In this application note, the U-Pb system was measured on a Nu TIMS using a combination of Daly (Pb) in peak jumping mode and Faraday (U) in static mode. The results summarized in Table 2 illustrate the stability of the Daly detector and Faraday cups on the Nu TIMS.

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Supplementary Table 1: Daly (Peak Jumping) SRM-982 200 pg + 2 uL silica gel (average blanks <0.2 pg)

Run ID	Date Run	Temp (ºC)	n	^{208}Pb (cps)	^{208}Pb/^{206}Pb	2SE within run errors	^{207}Pb/^{206}Pb (FC)	2SE	^{204}Pb/^{206}Pb (FC)	2SE	alpha/ amu
982-1a	04/15/23	1005	150	20000	0.99619	0.00047	0.467055	0.000029	0.027224	0.000012	0.0027
982-1b	04/15/23	1050	150	100000	0.99659	0.00041	0.467148	0.000029	0.027218	0.000012	0.0025
982-1c	04/15/23	1100	150	250000	0.99572	0.00038	0.467235	0.000029	0.027209	0.000012	0.0029
982-1d	04/15/23	1150	150	350000	0.99639	0.00033	0.466989	0.000029	0.027178	0.000012	0.0026
982-1e	04/15/23	1200	150	500000	0.99605	0.00027	0.467085	0.000029	0.027285	0.000011	0.0028
982-2a	04/16/23	1050	150	80000	0.99652	0.00045	0.467018	0.000030	0.027252	0.000012	0.0025
982-2b	04/16/23	1100	150	125000	0.99582	0.00043	0.466985	0.000029	0.027215	0.000012	0.0029
982-2c	04/16/23	1125	150	160000	0.99626	0.00042	0.467107	0.000029	0.027255	0.000012	0.0027
982-2d	04/16/23	1150	150	200000	0.99632	0.00040	0.467105	0.000029	0.027185	0.000012	0.0026
982-2e	04/16/23	1175	150	250000	0.99575	0.00036	0.467115	0.000029	0.027218	0.000012	0.0029
982-2f	04/16/23	1200	150	300000	0.99619	0.00032	0.466850	0.000028	0.027211	0.000011	0.0027
982-3a	04/25/23	1060	150	60000	0.99631	0.00046	0.467127	0.000030	0.027248	0.000012	0.0026
982-3b	04/25/23	1100	150	100000	0.99580	0.00043	0.467220	0.000030	0.027220	0.000012	0.0029
982-3c	04/25/23	1150	150	150000	0.99632	0.00042	0.467107	0.000029	0.027211	0.000012	0.0026
982-3d	04/25/23	1200	150	200000	0.99612	0.00038	0.467098	0.000029	0.027211	0.000012	0.0027
982-3e	04/25/23	1225	150	300000	0.99632	0.00037	0.467219	0.000028	0.027218	0.000011	0.0026
Mean					**0.99617**		**0.46709**		**0.027222**		**0.0027**
2StDev					**0.00054**		**0.00020**		**0.000053**		**0.0003**
Certified Ratios (Catanzaro et al., 1968)					1.0016		0.46707		0.027219		

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Supplementary Table 2: ID-TIMS U-Pb isotopic data for EARTHTIME ET535 refill

Sample Fraction ID	Wt. mg (a)	Detection mode (b)	Compositional Parameters: Th/U (c)	^{206}Pb* x10^{-13} mol (d)	mol % ^{206}Pb* (d)	Pb*/Pb$_c$ (d)	Pb$_c$ (pg) (d)	^{206}Pb/^{204}Pb (e)	Radiogenic Isotope Ratios: ^{208}Pb/^{206}Pb (f)	^{207}Pb/^{206}Pb (f)	% err (g)	^{207}Pb/^{235}U (f)	% err (g)	^{206}Pb/^{238}U (f)	% err (g)	corr. coef. (h)	Isotopic Ages: ^{207}Pb/^{206}Pb (g)	± (h)	^{207}Pb/^{235}U (g)	± (h)	^{206}Pb/^{238}U	± (g)
91500																						
A	0.049	D (Pb) F (U)	0.360	28.6431	99.88	236	2.96	14141	0.109	0.07490	0.045	1.851567	0.091	0.179291	0.054	0.931	1065.8	0.90	1063.99	0.60	**1063.10**	**0.53**
B	0.038	D (Pb) F (U)	0.355	23.2996	99.98	1731	0.33	106303	0.108	0.07489	0.041	1.852082	0.085	0.179365	0.048	0.957	1065.5	0.83	1064.17	0.56	**1063.51**	**0.47**
C	0.021	D (Pb) F (U)	0.316	13.0635	99.85	188	1.68	11412	0.096	0.07489	0.020	1.852403	0.045	0.179386	0.030	0.929	1065.7	0.41	1064.29	0.30	**1063.62**	**0.30**
D	0.040	D (Pb) F (U)	0.348	24.9530	99.93	391	1.55	23563	0.106	0.07490	0.021	1.852310	0.046	0.179368	0.031	0.930	1065.8	0.41	1064.25	0.30	**1063.52**	**0.30**
E	0.037	D (Pb) F (U)	0.381	23.5623	99.90	280	2.07	16656	0.115	0.07490	0.020	1.852802	0.044	0.179407	0.029	0.935	1065.9	0.40	1064.43	0.29	**1063.73**	**0.28**
weighted mean 206Pb/238U age = 1063.57 ± 0.15 Ma (2s); MSWD = 1.20 (n=5)																						
Reference Age = 1062.4 ± 0.4 Ma (Wiedenbeck et al., 1995)																						
AN2																						
A	0.01	D (Pb) F (U)	0.475	31.6968	99.98	1780	0.48	98069	0.132	0.18636	0.040	13.404447	0.084	0.521671	0.048	0.966	**2710.29**	**0.66**	2708.57	0.79	2706.26	1.05
B	0.01	D (Pb) F (U)	0.517	21.0767	99.98	1931	0.30	105409	0.143	0.18637	0.040	13.399250	0.083	0.521449	0.046	0.972	**2710.36**	**0.66**	2708.21	0.78	2705.32	1.01
C	0.01	D (Pb) F (U)	0.602	17.4326	99.98	1615	0.30	86666	0.166	0.18642	0.040	13.409091	0.084	0.521695	0.047	0.966	**2710.79**	**0.66**	2708.90	0.79	2706.37	1.04
D	0.01	D (Pb) F (U)	0.601	17.2332	99.99	2362	0.20	126714	0.166	0.18644	0.040	13.411551	0.088	0.521733	0.054	0.951	**2710.97**	**0.66**	2709.07	0.83	2706.53	1.20
weighted mean 207Pb/206Pb age = 2710.60 ± 0.33 Ma (2s); MSWD = 1.00 (n=4)																						
Reference Age = 2710.44 ± 0.32 Ma (Wall et al., 2016)																						
PLES535																						
A	0.01	D (Pb) F (U)	0.105	3.3442	99.89	241	0.31	16157	0.033	0.05325	0.079	0.394315	0.144	0.053727	0.071	0.952	338.6	1.79	337.52	0.41	**337.36**	**0.23**
B	0.01	D (Pb) F (U)	0.105	3.3488	99.89	237	0.32	15849	0.033	0.05322	0.080	0.393929	0.144	0.053709	0.071	0.952	337.1	1.80	337.24	0.41	**337.25**	**0.23**
C	0.01	D (Pb) F (U)	0.104	3.3338	99.87	210	0.35	14089	0.033	0.05325	0.081	0.394028	0.146	0.053687	0.072	0.952	338.6	1.84	337.31	0.42	**337.12**	**0.24**
D	0.01	D (Pb) F (U)	0.104	3.3443	99.89	240	0.31	16088	0.033	0.05325	0.077	0.394022	0.142	0.053689	0.071	0.962	338.5	1.74	337.30	0.41	**337.13**	**0.23**
E	0.01	D (Pb) F (U)	0.105	3.3449	99.90	257	0.29	17212	0.033	0.05323	0.081	0.394060	0.144	0.053712	0.071	0.940	337.7	1.84	337.33	0.41	**337.27**	**0.23**
weighted mean 206Pb/238U age = 337.23 ± 0.10 Ma (2s); MSWD = 0.77 (n=5)																						
Reference Age = 337.201 ± 0.025 Ma (Widmann et al., 2019)																						
ET100																						
1	0.005	D (Pb) F (U)	0.067	2.3206	99.71	93	0.55	6458	0.021	0.04802	0.131	0.103574	0.203	0.01564	0.088	0.891	100.3	3.1	100.07	0.19	**100.061**	**0.088**
2	0.005	D (Pb) F (U)	0.069	2.3529	99.70	89	0.59	6127	0.022	0.04805	0.137	0.103742	0.208	0.01566	0.088	0.881	101.7	3.2	100.22	0.20	**100.161**	**0.088**
3	0.005	D (Pb) F (U)	0.067	1.3087	99.62	71	0.41	4904	0.021	0.04804	0.166	0.103690	0.231	0.01566	0.091	0.812	101.0	3.9	100.18	0.22	**100.143**	**0.091**
4	0.005	D (Pb) F (U)	0.066	2.4856	99.66	77	0.71	5363	0.021	0.04800	0.153	0.103559	0.219	0.01565	0.089	0.840	99.2	3.6	100.06	0.21	**100.090**	**0.088**
5	0.005	D (Pb) F (U)	0.070	2.2694	99.75	107	0.47	7395	0.022	0.04807	0.128	0.103764	0.199	0.01566	0.089	0.882	102.5	3.0	100.24	0.19	**100.151**	**0.088**
6	0.005	D (Pb) F (U)	0.064	2.1631	99.57	61	0.78	4258	0.020	0.04804	0.175	0.103742	0.241	0.01566	0.092	0.809	101.1	4.1	100.22	0.23	**100.187**	**0.091**
7	0.005	D (Pb) F (U)	0.069	2.1416	99.76	110	0.43	7609	0.022	0.04807	0.125	0.103815	0.200	0.01566	0.095	0.882	102.6	3.0	100.29	0.19	**100.196**	**0.094**
8	0.005	D (Pb) F (U)	0.067	3.0343	99.63	73	0.92	5040	0.022	0.04800	0.161	0.103675	0.226	0.01566	0.089	0.824	99.4	3.8	100.16	0.22	**100.194**	**0.088**
9	0.005	D (Pb) F (U)	0.069	2.6926	99.70	88	0.68	6066	0.022	0.04804	0.140	0.103637	0.209	0.01565	0.088	0.867	101.1	3.3	100.13	0.20	**100.087**	**0.088**
weighted mean 206Pb/238U age = 100.140 ± 0.030 Ma (2s); MSWD = 1.28 (n=9)																						
Reference Age = 100.173 ± 0.003 Ma (Schaltegger et al., 2021)																						
ET500 (j)																						
1	0.005	D (Pb) F (U)	0.086	3.9685	99.80	136	0.65	9245	0.027	0.05728	0.089	0.636976	0.145	0.08066	0.070	0.889	502.2	2.0	500.43	0.57	**500.05**	**0.34**
2	0.005	D (Pb) F (U)	0.086	2.2095	99.77	117	0.42	7989	0.027	0.05724	0.093	0.636656	0.149	0.08066	0.071	0.882	501.0	2.0	500.23	0.59	**500.07**	**0.34**
3	0.005	D (Pb) F (U)	0.086	2.2322	99.75	107	0.47	7278	0.027	0.05725	0.098	0.636029	0.152	0.08058	0.069	0.874	501.2	2.2	499.84	0.60	**499.56**	**0.33**
4	0.005	D (Pb) F (U)	0.084	2.2830	99.69	87	0.58	5966	0.026	0.05718	0.113	0.635415	0.164	0.08059	0.070	0.836	498.5	2.5	499.46	0.65	**499.67**	**0.33**
5	0.005	D (Pb) F (U)	0.086	2.5079	99.72	95	0.59	6504	0.027	0.05718	0.110	0.636306	0.161	0.08072	0.070	0.829	498.3	2.4	500.02	0.63	**500.39**	**0.34**
6	0.005	D (Pb) F (U)	0.085	2.5016	99.70	91	0.61	6228	0.027	0.05722	0.115	0.636540	0.164	0.08068	0.068	0.820	500.2	2.5	500.16	0.65	**500.16**	**0.33**
7	0.005	D (Pb) F (U)	0.082	2.5222	99.70	90	0.62	6184	0.026	0.05717	0.111	0.635921	0.161	0.08067	0.068	0.834	498.3	2.4	499.78	0.64	**500.11**	**0.33**
8	0.005	D (Pb) F (U)	0.084	2.5214	99.73	102	0.55	6950	0.026	0.05715	0.100	0.635427	0.153	0.08064	0.069	0.866	497.3	2.2	499.47	0.61	**499.95**	**0.33**
9	0.005	D (Pb) F (U)	0.083	2.0065	99.72	98	0.46	6681	0.026	0.05727	0.106	0.637026	0.158	0.08067	0.070	0.843	502.0	2.3	500.46	0.62	**500.13**	**0.34**
10	0.005	D (Pb) F (U)	0.087	2.4881	99.72	98	0.57	6657	0.027	0.05724	0.102	0.636798	0.156	0.08069	0.069	0.863	500.7	2.3	500.32	0.62	**500.23**	**0.33**
11	0.005	D (Pb) F (U)	0.086	3.0819	99.77	116	0.59	7904	0.027	0.05725	0.097	0.636657	0.151	0.08065	0.070	0.866	501.4	2.1	500.23	0.59	**499.99**	**0.34**
12	0.005	D (Pb) F (U)	0.086	2.8917	99.82	148	0.44	10071	0.027	0.05724	0.086	0.636396	0.143	0.08064	0.070	0.895	500.8	1.9	500.07	0.56	**499.91**	**0.33**
13	0.005	D (Pb) F (U)	0.082	2.9251	99.64	76	0.86	5184	0.026	0.05724	0.126	0.636973	0.174	0.08071	0.069	0.801	500.6	2.8	500.43	0.69	**500.39**	**0.33**
14	0.005	D (Pb) F (U)	0.086	3.4230	99.80	134	0.57	9135	0.027	0.05724	0.091	0.636602	0.146	0.08066	0.070	0.884	500.8	2.0	500.20	0.58	**500.07**	**0.34**
15	0.005	D (Pb) F (U)	0.085	7.5314	99.79	130	1.29	8872	0.027	0.05723	0.089	0.636600	0.160	0.08068	0.097	0.875	500.4	2.0	500.20	0.63	**500.16**	**0.47**
weighted mean 206Pb/238U age = 500.052 ± 0.088 Ma (2s); MSWD = 1.83 (n=15)																						
ET2000																						
1	0.005	D (Pb) F (U)	0.088	3.3489	99.71	99	0.80	6380	0.025	0.12296	0.093	6.164838	0.176	0.36363	0.094	0.943	**1999.62**	**1.64**	1999.48	1.54	1999.34	1.62
2	0.005	D (Pb) F (U)	0.087	4.6268	99.68	89	1.23	5730	0.025	0.12283	0.091	6.159082	0.176	0.36368	0.094	0.951	**1997.72**	**1.62**	1998.66	1.53	1999.58	1.61
3	0.005	D (Pb) F (U)	0.090	2.7992	99.76	120	0.55	7700	0.026	0.12303	0.089	6.165140	0.174	0.36344	0.095	0.950	**2000.62**	**1.58**	1999.52	1.52	1998.46	1.63
4	0.005	D (Pb) F (U)	0.090	3.1125	99.72	104	0.71	6722	0.026	0.12294	0.093	6.163848	0.176	0.36362	0.095	0.940	**1999.35**	**1.65**	1999.34	1.54	1999.33	1.64
5	0.005	D (Pb) F (U)	0.088	2.8752	99.70	96	0.71	6168	0.025	0.12297	0.092	6.166859	0.177	0.36372	0.096	0.943	**1999.75**	**1.63**	1999.76	1.55	1999.78	1.65
6	0.005	D (Pb) F (U)	0.090	4.2752	99.70	95	1.06	6135	0.026	0.12298	0.092	6.166242	0.176	0.36364	0.095	0.945	**1999.97**	**1.63**	1999.68	1.54	1999.39	1.62
7	0.005	D (Pb) F (U)	0.090	3.9252	99.68	90	1.03	5796	0.026	0.12308	0.095	6.170360	0.178	0.36360	0.095	0.937	**2001.35**	**1.68**	2000.26	1.55	1999.20	1.64
8	0.005	D (Pb) F (U)	0.089	4.0222	99.69	91	1.04	5878	0.026	0.12295	0.092	6.163575	0.176	0.36359	0.095	0.946	**1999.46**	**1.63**	1999.30	1.54	1999.15	1.63
9	0.005	D (Pb) F (U)	0.095	3.0742	99.85	193	0.38	12379	0.027	0.12303	0.086	6.166128	0.171	0.36350	0.093	0.958	**2000.61**	**1.52**	1999.66	1.49	1998.74	1.60
10	0.005	D (Pb) F (U)	0.091	4.2576	99.75	117	0.86	7540	0.026	0.12304	0.090	6.167393	0.173	0.36354	0.092	0.952	**2000.77**	**1.60**	1999.84	1.51	1998.94	1.59
11	0.005	D (Pb) F (U)	0.091	3.0612	99.75	113	0.64	7262	0.026	0.12299	0.092	6.167351	0.176	0.36368	0.095	0.943	**2000.08**	**1.63**	1999.83	1.53	1999.60	1.63
12	0.005	D (Pb) F (U)	0.090	2.7970	99.70	94	0.70	6080	0.026	0.12297	0.093	6.162044	0.177	0.36342	0.096	0.941	**1999.80**	**1.65**	1999.08	1.55	1998.39	1.65
13	0.005	D (Pb) F (U)	0.089	1.4777	99.74	112	0.31	7208	0.026	0.12291	0.091	6.156671	0.181	0.36328	0.104	0.935	**1998.95**	**1.61**	1998.32	1.58	1997.71	1.79
14	0.005	D (Pb) F (U)	0.089	3.5402	99.71	100	0.84	6453	0.026	0.12299	0.091	6.167716	0.175	0.36371	0.094	0.950	**2000.06**	**1.61**	1999.89	1.53	1999.72	1.61
weighted mean 207Pb/206Pb age = 1999.87 ± 0.43 Ma (2s); MSWD = 1.19 (n=14)																						
Reference Age = 1999.935 ± 0.063 Ma (Schaltegger et al., 2021)																						

(a) Nominal fraction weights
(b) Detection mode for Pb acquisition, D = ion counting Daly ; F = Faraday
(c) Nominal U and total Pb concentrations
(d) Pb* and Pbc represent radiogenic and common Pb, respectively; mol % ^{206}Pb* with respect to radiogenic, blank and initial common Pb.
(e) Measured ratio corrected for spike and fractionation only. Daly analyses, based on analysis of SRM-981 and SRM-982.
(f) Corrected for fractionation, spike, and common Pb; up to 13 pg of common Pb was assumed to be procedural blank: ^{206}Pb/^{204}Pb = 18.50 ± 0.60%; ^{207}Pb/^{204}Pb = 15.50 ± 0.50%; ^{208}Pb/^{204}Pb = 38.50 ± 1.00% (all uncertainties 1-sigma). Excess over blank was assigned to initial common Pb.
(g) Errors are 2-sigma, propagated using the algorithms of Schmitz and Schoene (2007)
(h) Calculations are based on the decay constants of Jaffey et al. (1971).
(i) Corrected for fractionation, spike, and blank Pb only.
(j) No published reference value for ET500

Nu TIMS

Professor Dominique Weis is Director of PCIGR and a Killam Professor at the University of British Columbia in Vancouver, Canada. Her innovative use of trace element and isotope geochemistry addresses (1) the origin, source and pathways of mantle plumes through time; (2) Indigenous-led questions about the origins, distribution and trade of artifacts; and (3) the impact of humans and metals on the environment. She has led major initiatives, including organizing and hosting the 2008 Goldschmidt Conference at UBC, building the nUBC analytical facility at PCIGR to welcome users worldwide, and attaining grant funding for various research networks and projects.

Dr. Weis has over 240 peer-reviewed papers in high-impact scholarly publications, and she has served on the editorial boards of three journals. Through teaching and mentorship, Dr. Weis supports the next generation of geoscientists, especially women. She has received numerous awards and is sought after to give lectures to academic, government and general audiences. Dr. Weis is a three-term Canada Research Chair and fellow of the American Geophysical Union and Geochemical Society. She serves on committees for the AGU, Geochemical Society, and NSERC (Canada). Hailing from Belgium, Dr. Weis is a graduate of the Université Libre de Bruxelles.

Dr. Corey Wall obtained his B.Sc. (Honours) and Ph.D. from the Department of Earth, Ocean, and Atmospheric Sciences at the University of British Columbia. He joined the Isotope Geology Laboratory (IGL) research team at Boise State University as a postdoctoral fellow and then as National Science Foundation Laboratory Technical Support Scientist. His responsibilities included training students and researchers in all aspects of isotope geochemistry and mass spectrometry. In 2021, Dr. Wall returned to UBC as facility manager and U-Pb geochronology specialist at the Pacific Centre for Isotopic and Geochemical Research.

Dr. Wall's main interests involve the application of high-precision U-Pb geochronology to large layered intrusions. New zircon pre-treatment techniques (i.e., chemical abrasion), reduction of Pb-blanks, the development of multi-element isotopic tracers, and improvements in instrumental characterization have enhanced dating precision (uncertainty <0.1% per analysis). This improvement allows for the recognition of distinct magma pulses at timescales aimed at sequencing Earth's history.

Additionally, Dr. Wall has pursued studies of ion emitter chemistry and enhanced ionization efficiency, characterization of mineral standard materials for in situ U-Pb geochronology, the tectonomagmatism of the Early Cambrian Oklahoma Aulacogen large igneous province, and the integration of zircon geochemistry and rhyolite-MELTS modeling of silicic magma petrogenesis.