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Data Repository 1

Lateral magma propagation during the emplacement of La Gloria Pluton, central Chile

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LA-ICP-MS U–PB METHODOLOGY

For U–Pb analyses, zircon crystals were separated from rock samples using routine crushing, grinding, Gemini Table, heavy liquid and Frantz magnetic separation at the Geology Department, University of Chile. About 60 zircons per sample were mounted in epoxy resin, polished, characterized by cathodoluminescence imaging, and analyzed by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) at ETH Zürich. Detailed parameters of the analytical setup and procedures for LA-ICP-MS U-Th-Pb geochronology as well as results for samples and secondary reference materials are reported in tables DR1–3 following community-derived guidelines of Horstwood et al. (2016).

We calculated weighted mean sample ages from individual LA-ICP-MS U–Pb dates (Fig. 2A of the main text and table S1 below) but used them in a qualitative way to illustrate the age progression along La Gloria Pluton. Weighted mean ages of individual hand samples are not geologically meaningful for plutonic samples that display protracted crystallization histories of up to 200 k.y. (shown here with ID-TIMS dating) and as much as 700 k.y. in other plutons (Schoene et al., 2012; Samperton et al., 2015). In that context, the apparent age dispersion (elevated MSWD of LA-ICP-MS results) in individual samples partly reflects the real zircon age spread, and partly analytical sources of error in these measurements.

Even given these complexities, the calculated weighted means of LGP LA-ICP-MS dates are systematically offset by 1–2% from the benchmark ID-TIMS dates (Fig. 2). A likely explanation lies in the fact that the LA-ICP-MS analyses were performed on unannealed zircons without applying an alpha-dose correction for young zircons (Sliwinski et al., 2017). This key correction was developed after the LGP analyses were performed and could not be retroactively applied, as a more complete selection of secondary reference materials would be required. However, the slight inaccuracy of our LA-ICP-MS data has no bearing on the first-order conclusions of our study, where the within-pluton age progression is convincingly shown with ID-TIMS dates.

Table DR1

Sample	Coordinates			LA-ICP-MS			
Number	N [m]	E [m]	H [m]	# Points	MSWD	Age [Ma]	±2σ [Ma]
LG19	6,300,210	390,173	3,292	31	2.5	10.27	0.11
LG17	6,298,794	392,301	2,486	44	3.1	9.92	0.11
LG42	6,295,101	391,216	2,006	57	1.9	10.31	0.11
LG37	6,293,345	391,737	1,527	77	2.6	10.42	0.11
LG29	6,292,516	393,543	1,480	39	2.7	10.12	0.12
LG16	6,292,150	395,962	1,960	59	4	10.31	0.12
LG12	6,288,818	397,664	2,717	54	2.7	10.34	0.11
LG07	6,285,249	397,083	3,557	52	1.3	10.49	0.11
LG03	6,283,070	397,263	3,049	109	1.3	10.54	0.11
LG01	6,280,403	397,216	3,057	40	6.2	11.04	0.13

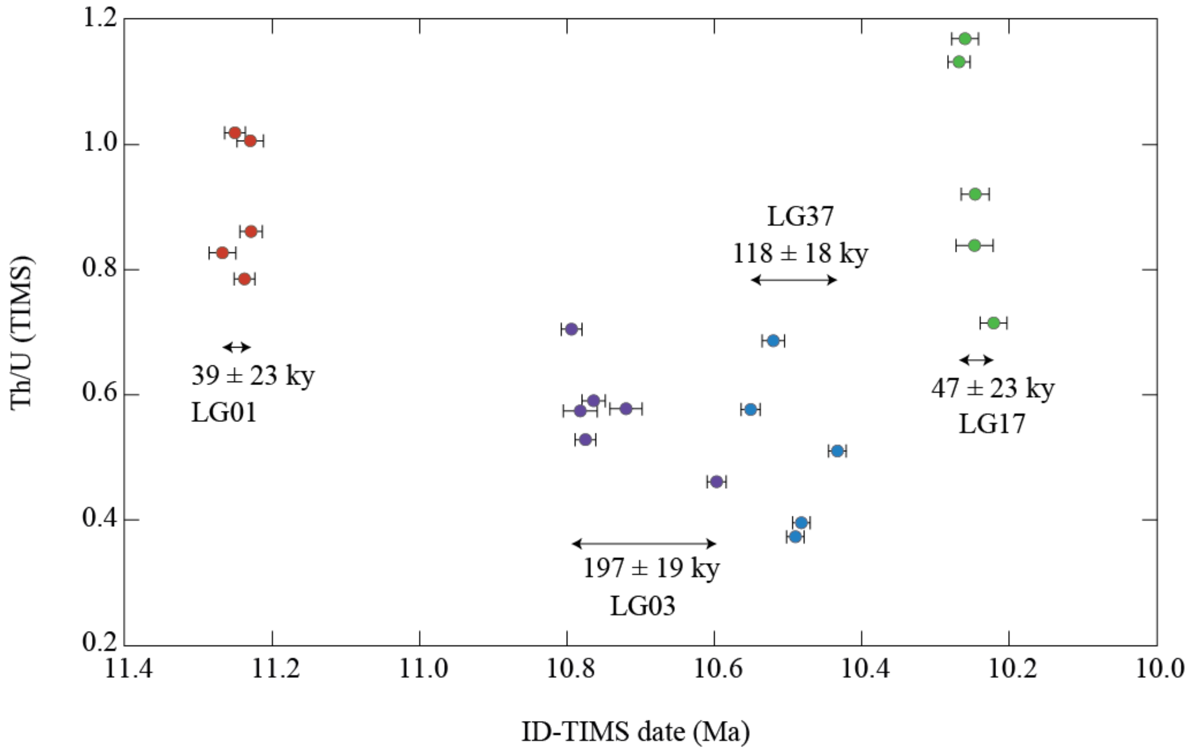

Fig. DR1. Whole-grain Th/U of dated zircons from ID-TIMS analyses. Zircon crystals from the pluton center (LG03, LG37) have systematically lower Th/U ratios as well as longer apparent crystallization intervals.

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Table DR2

LA-ICP-MS U-(Th-)Pb Metadata

Laboratory and Sample Preparation	
Laboratory name	Dept of Earth Science, ETH Zurich
Sample type/mineral	Magmatic Zircons
Sample preparation	Conventional mineral separation, 1 inch resin mount, 1 μm polish to finish
Imaging	CL, Quanta200S, 10 kV
Laser ablation system	
Make, Model and type	ASI (Resonetics) Resolution S155
Ablation cell and volume	Laurin Technic, 2 volume cell, effective volume *ca* . 1 cm^3
Laser wavelength (nm)	193 nm
Pulse width (ns)	25 ns
Fluence ($J\ cm^{-2}$)	~2 $J\ cm^{-2}$
Repetition rate (Hz)	5 Hz
Ablation duration (s)	40 s
Ablation pit depth / ablation rate	~16 μm pit depth, equivalent to 0.08 μm/pulse
Spot diameter (μm) nominal/actual	30 μm / 30 μm
Sampling mode / pattern	Static spot ablation
Carrier gas	100% He in the cell, Ar make-up gas combined in cell above ablation in funnel.
Cell carrier gas flow ($l\ min^{-1}$)	0.7 $l\ min^{-1}$
ICP-MS Instrument	
Make, Model and type	Thermo Element XR, Sector-field single collector ICP-MS
Sample introduction	direct
RF power (W)	1400 W - 1550W (tuned daily)
Make-up gas flow ($l\ min^{-1}$)	0.90 - 0.99 $l\ min^{-1}$ Ar (tuned daily)

Detection system	triple (pulse counting, analog, Faraday) cross calibrated daily
Masses measured (amu)	202, 204, 206, 207, 208, 232, 235, 238
Integration time per peak/dwell times (ms)	10 ms (202, 208, 232, 235, 238), 20 ms (204), 90 ms (206), 75ms (207)
Total integration time per output data point (s)	0.243 s
Dead time (ns)	8
Typical oxide rate (ThO/Th)	0.18%
Typical doubly charged rate (Ba^{++}/Ba^{+})	3.50%
Data Processing	
Gas blank	10 s
Calibration strategy	GJ-1 used as primary reference material, Plešovice, Temora and 91500 used as secondaries/validation
Reference Material info	GJ-1 (Jackson *et al* . 2004) Plešovice (Slama *et al* . 2008) Temora (Black *et al.* 2003) 91500 (Wiedenbeck et al. 1995)
Data processing package used / Correction for LIEF	Iolite 2.5, VizualAge for uncertainty propagation and age calculation. LIEF correction assumes reference material and samples behave identically.
Mass discrimination	normalised to reference material
Common-Pb correction, composition and uncertainty	No common-Pb correction applied to the data.
Uncertainty level and propagation	Ages are quoted at 2*s* absolute, propagation is by quadratic addition. Reproducibility and age uncertainty of reference material are propagated where appropriate.

Quality control / Validation	Plešovice – Wtd ave $^{206}Pb/^{238}U$ age = 336 ± 3.4 (2s, MSWD = 1.5, n = 39) (0.15% Wtd ave uncert. (internal), 1.0% Total external uncert.)
	Temora - Wtd ave 206Pb/238U age = 415 ± 4 (2s, MSWD = 1.6, n = 39) (0.18% Wtd ave uncert. (internal), 1.0% total external uncert.)
	91500 – Wtd ave $^{206}Pb/^{238}U$ age = 1063 ± 11 (2*s* , MSWD = 0.61, n = 38) (0.15% Wtd ave uncert. (internal), 1.0% Total external uncert.)
	Systematic uncertainty for propagation is 1.0% (2*s*).

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Table DR3
LA-ICP-MS data

Table DR4

La Gloria zircon ID-TIMS data

Fraction	Th/U a	Pb* (pg) b	Pbc (pg) c	Pb*/Pbc d	206Pb/204Pb e	206Pb/238U f	±2σ %	207Pb/235U f	±2σ %	207Pb/206Pb f	±2σ %	Corr. coef.	206Pb/238U g	±2σ abs	206Pb/238U <Th> h	±2σ abs	207Pb/235U g	±2σ abs
	Composition				Isotopic Ratios								Dates (Ma)					
LG1701																		
LG1701_z1	0.92	1.35	0.16	8	472	0.0015774	0.162	0.010401	2.37	0.04784	2.26	0.686	10.161	0.016	10.246	0.019	10.51	0.25
LG1701_z2	0.71	1.63	0.17	9	546	0.0015736	0.146	0.010164	2.08	0.04687	1.98	0.718	10.136	0.015	10.221	0.018	10.27	0.21
LG1701_z3	1.13	1.25	0.07	19	987	0.0015809	0.101	0.010127	1.38	0.04648	1.30	0.740	10.183	0.010	10.268	0.015	10.23	0.14
LG1701_z4	1.17	1.98	0.06	32	1627	0.0015797	0.140	0.010129	1.51	0.04653	1.39	0.898	10.175	0.014	10.260	0.018	10.23	0.15
LG1701_z5	0.84	0.93	0.05	17	956	0.0015776	0.229	0.010426	2.77	0.04795	2.56	0.913	10.162	0.023	10.247	0.025	10.53	0.29
LG3701																		
LG3701_z1	0.51	6.79	0.16	41	2472	0.0016065	0.060	0.010809	0.46	0.04882	0.41	0.725	10.3478	0.0062	10.433	0.012	10.917	0.050
LG3701_z2	0.37	8.87	0.43	21	1281	0.0016153	0.063	0.010724	0.71	0.04817	0.69	0.479	10.4046	0.0066	10.490	0.012	10.831	0.077
LG3701_z3	0.40	8.06	0.11	72	4418	0.0016140	0.048	0.010627	0.38	0.04777	0.35	0.498	10.3964	0.0050	10.482	0.012	10.733	0.040
LG3701_z4	0.69	1.45	0.09	16	909	0.0016200	0.101	0.010645	1.34	0.04768	1.28	0.658	10.435	0.011	10.520	0.015	10.75	0.14
LG3701_z5	0.58	1.99	0.10	20	1194	0.0016248	0.077	0.010423	1.00	0.04655	0.95	0.676	10.4655	0.0081	10.551	0.013	10.53	0.10
LG0302																		
LG0302_z1	0.57	13.51	0.07	193	9782	0.0016608	0.186	0.010790	0.38	0.04714	0.31	0.607	10.697	0.020	10.782	0.023	10.897	0.041
LG0302_z2	0.53	25.90	0.21	126	7431	0.0016596	0.088	0.010802	0.23	0.04723	0.19	0.617	10.6899	0.0094	10.775	0.014	10.909	0.025
LG0302_z3	0.46	15.61	0.18	87	5225	0.0016320	0.074	0.010602	0.24	0.04714	0.20	0.577	10.5119	0.0078	10.597	0.013	10.708	0.026
LG0302_z4	0.71	30.77	0.43	72	4057	0.0016627	0.079	0.010827	0.25	0.04725	0.22	0.490	10.7093	0.0085	10.794	0.014	10.935	0.027
LG0302_z5	0.59	15.63	0.51	31	1802	0.0016579	0.116	0.010829	0.54	0.04739	0.50	0.391	10.679	0.012	10.764	0.016	10.937	0.059
LG0302_z6	0.58	8.17	0.35	23	1181	0.0016511	0.187	0.010768	2.43	0.04732	2.31	0.700	10.635	0.020	10.720	0.022	10.88	0.26
LG0103																		
LG0103_z1	0.86	3.02	0.15	20	1079	0.0017302	0.093	0.011089	1.09	0.04651	1.02	0.716	11.144	0.010	11.229	0.015	11.20	0.12
LG0103_z2	1.01	1.41	0.11	12	666	0.0017304	0.137	0.011041	1.79	0.04630	1.68	0.784	11.145	0.015	11.230	0.018	11.15	0.20
LG0103_z3	0.79	3.46	0.12	29	1639	0.0017315	0.080	0.011220	0.80	0.04701	0.74	0.748	11.1526	0.0089	11.238	0.014	11.329	0.090
LG0103_z4	0.83	2.07	0.11	19	1082	0.0017363	0.127	0.011486	2.13	0.04800	2.05	0.638	11.183	0.014	11.268	0.018	11.60	0.25
LG0103_z5	1.02	2.91	0.10	30	1602	0.0017336	0.086	0.011048	0.93	0.04624	0.87	0.804	11.1660	0.0095	11.251	0.014	11.16	0.10

a Th contents calculated from radiogenic 208Pb and 230Th-corrected 206Pb/238U date of the sample, assuming concordance between U-Pb Th-Pb systems.

b Total mass of radiogenic Pb.

c Total mass of common Pb.

d Ratio of radiogenic Pb (including 208Pb) to common Pb.

e Measured ratio corrected for fractionation and spike contribution only.

f Measured ratios corrected for fractionation, tracer and blank. The blank composition used was an average of 14 total procedural blank measurements performed over the course of this study: 206Pb/204Pb = 18.41 ± 0.39, 207Pb/204Pb = 15.19 ± 0.39, 208Pb/204Pb = 36.93 ± 0.91 (2σ)

g Isotopic dates calculated using λ238 = 1.55125E-10 (Jaffey et al. 1971) and λ235 = 9.8485E-10 (Jaffey et al. 1971).

h Corrected for initial Th/U disequilibrium using a fixed partition coefficient ratio DTh/DU=0.218 ± 0.097 (2σ) (Szymanowski et al. 2017).