Charleston LA software workshop Statistical Interpretation of Age Information, LA-ICP-MS and beyond

Framing the problem – some conclusions from the 2011 interlaboratory comparison

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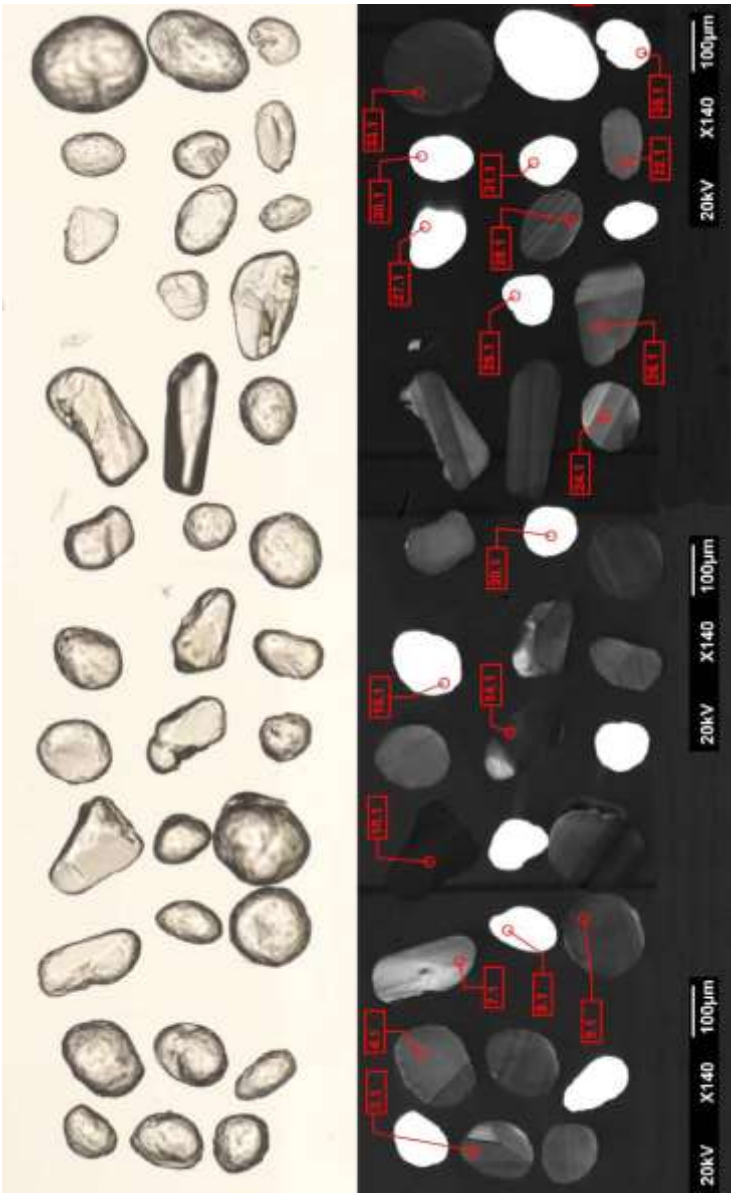
Preparation of synthetic detrital samples

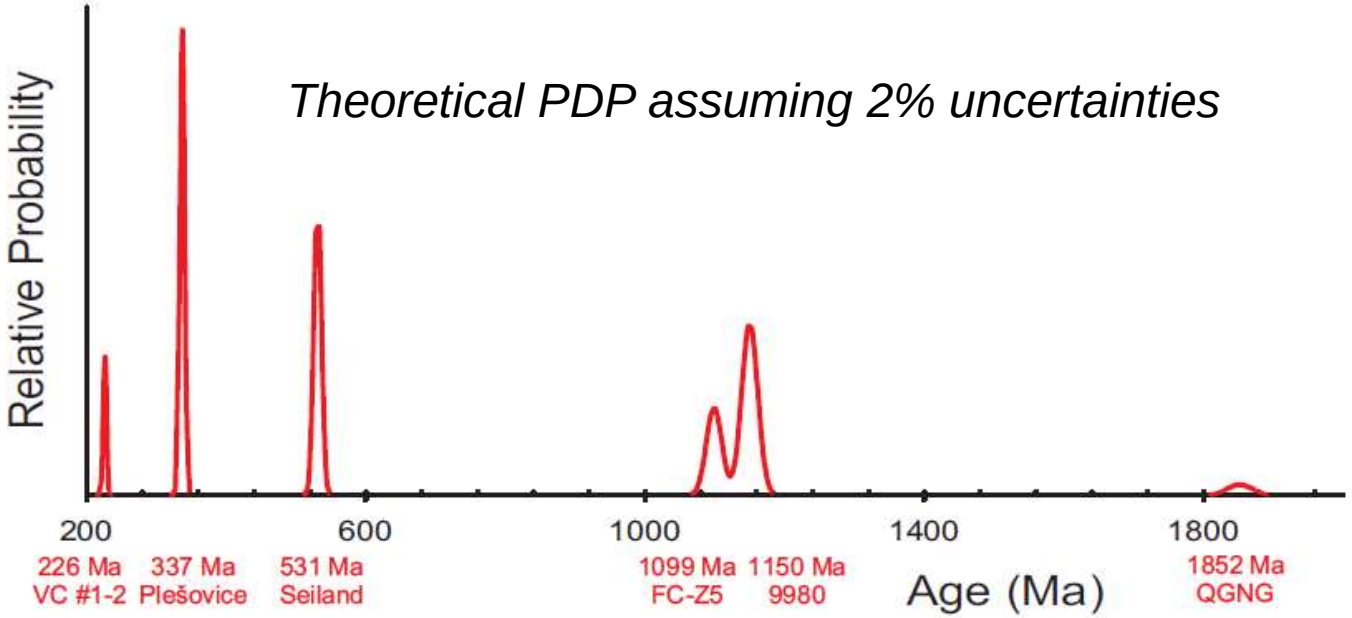


Courtesy of ILC participant

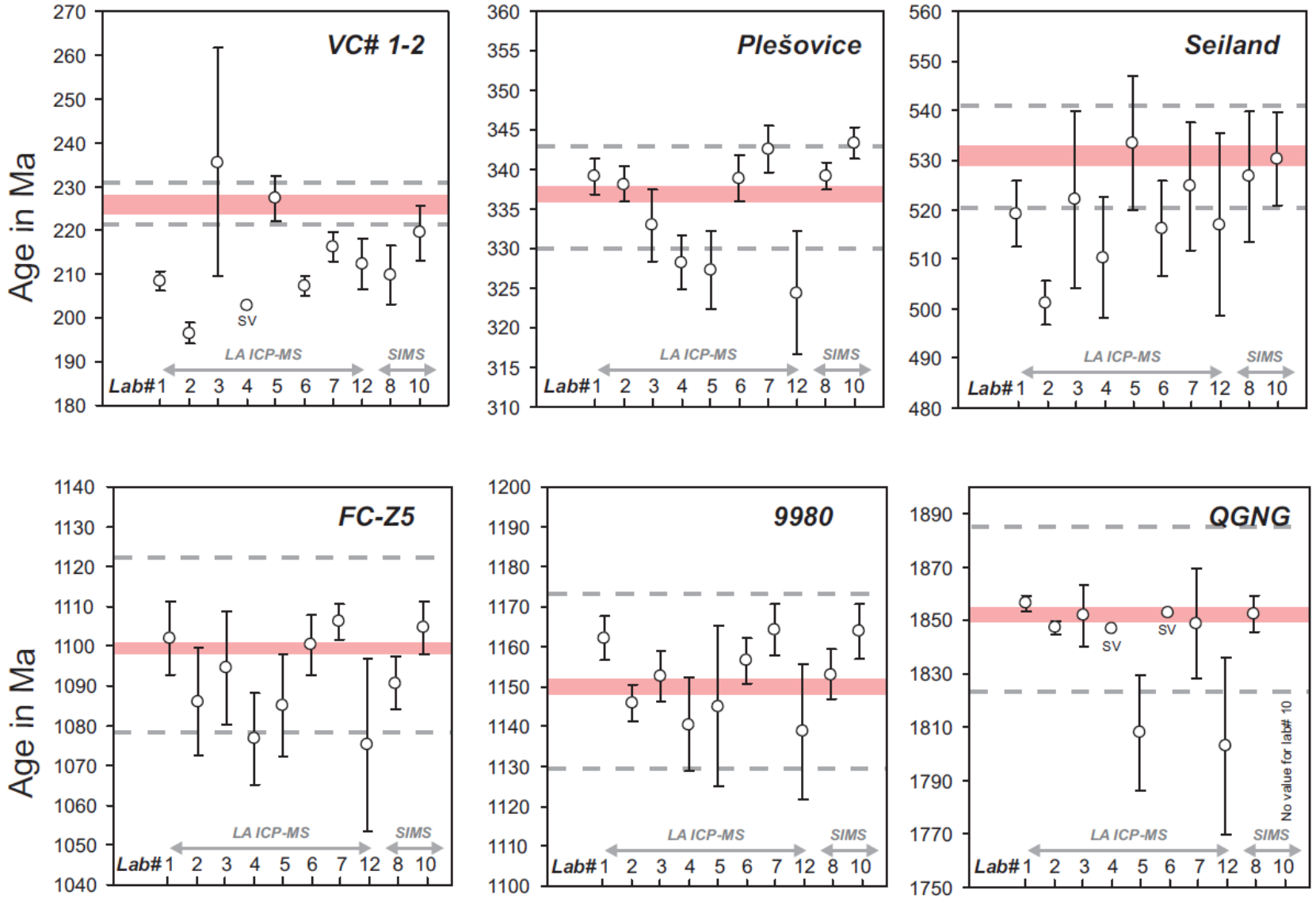
Reference zircons used in synthetic detrital samples

	<100 µm % [n]	>100 µm % [n]	Total % [n]
VC #1-2 (226±2 Ma, *Kloetzli et al. 2009*)	2.4% [5]	2.4% [5]	4.8% [10]
Plešovice (337±1 Ma, *Slama et al. 2008*)	12% [25]	12% [25]	24% [50]
Seiland (531±2 Ma, *Pedersen et al. 1989*)	24% [50]	0% [0]	24% [50]
FC-Z5 (1099.3±0.3 Ma, *Paces&Miller 1993*)	7.2% [15]	7.2% [15]	14.4% [30]
9980 (1150±2 Ma, *Corfu unpubl.*)	14.9% [31]	14.9% [31]	29.8% [62]
QGNG (1852±1 Ma, *Black et al. 2003*)	1.4% [3]	1.4% [3]	2.9% [6]

All samples are near concordant and do not normally require significant common Pb correction

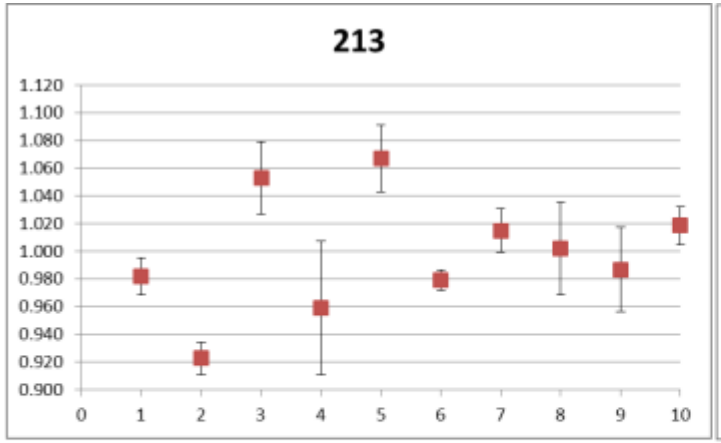


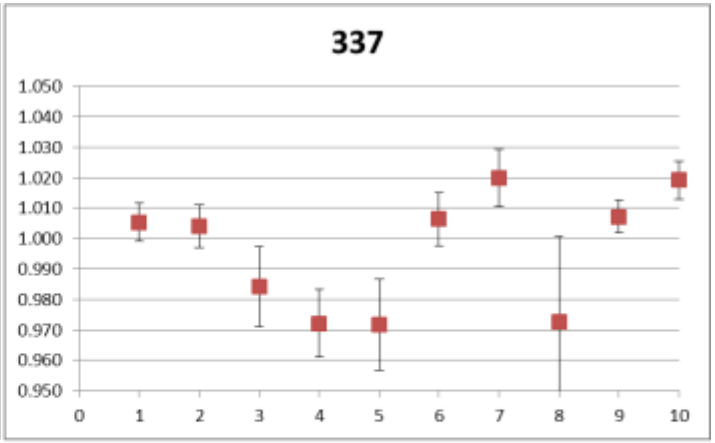
U-Pb Concordia age accuracy

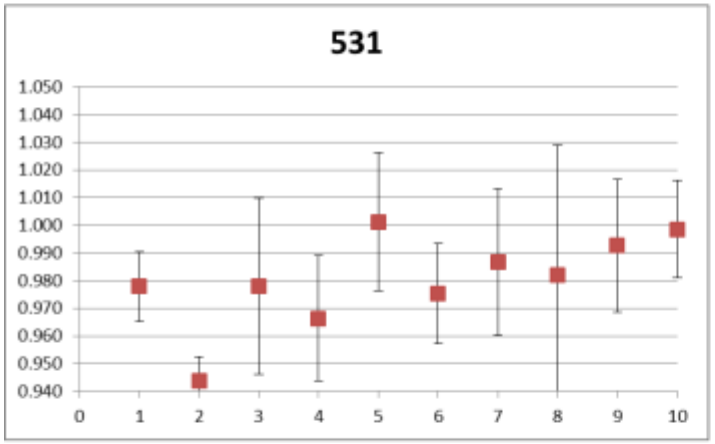


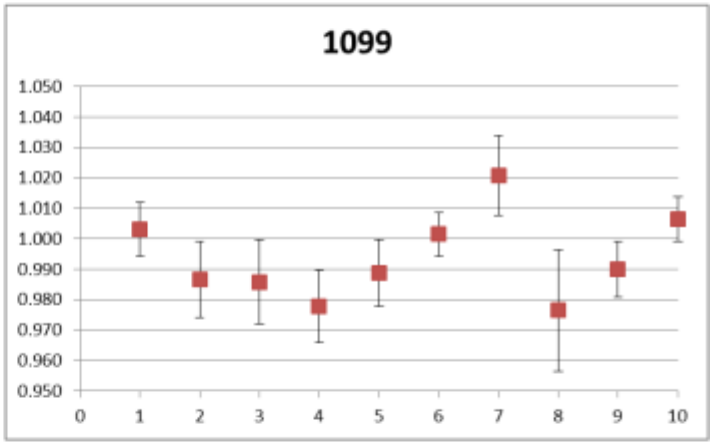
Note: mean U-Pb concordia ages, data uncertainties are 1SD, reference TIMS ages are ±2σ, dashed lines – ±2% limits, sv – single value

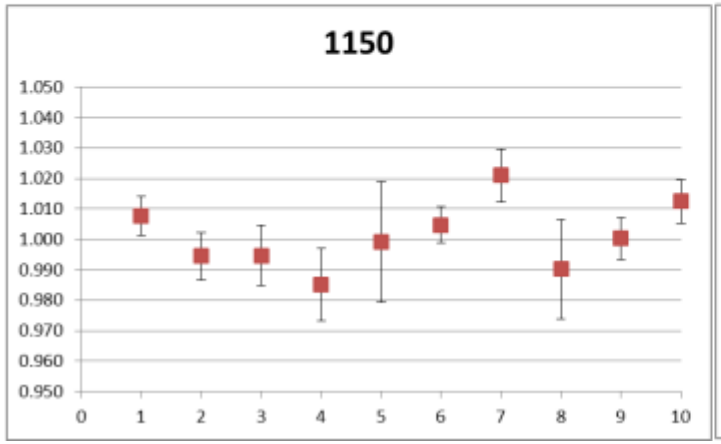
206Pb/238U age relative accuracy
(uncertainties are 1SD)

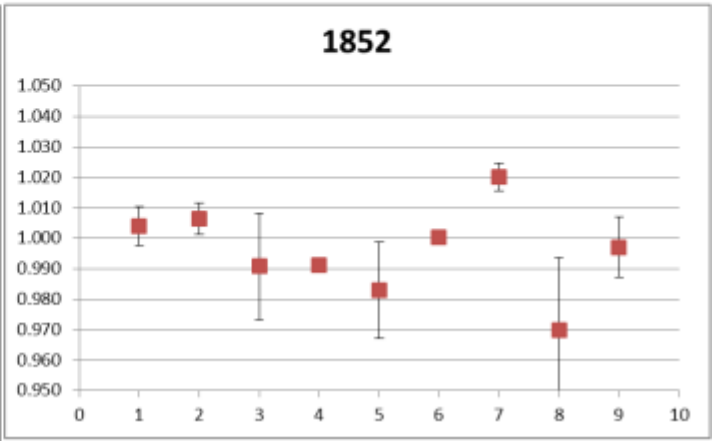




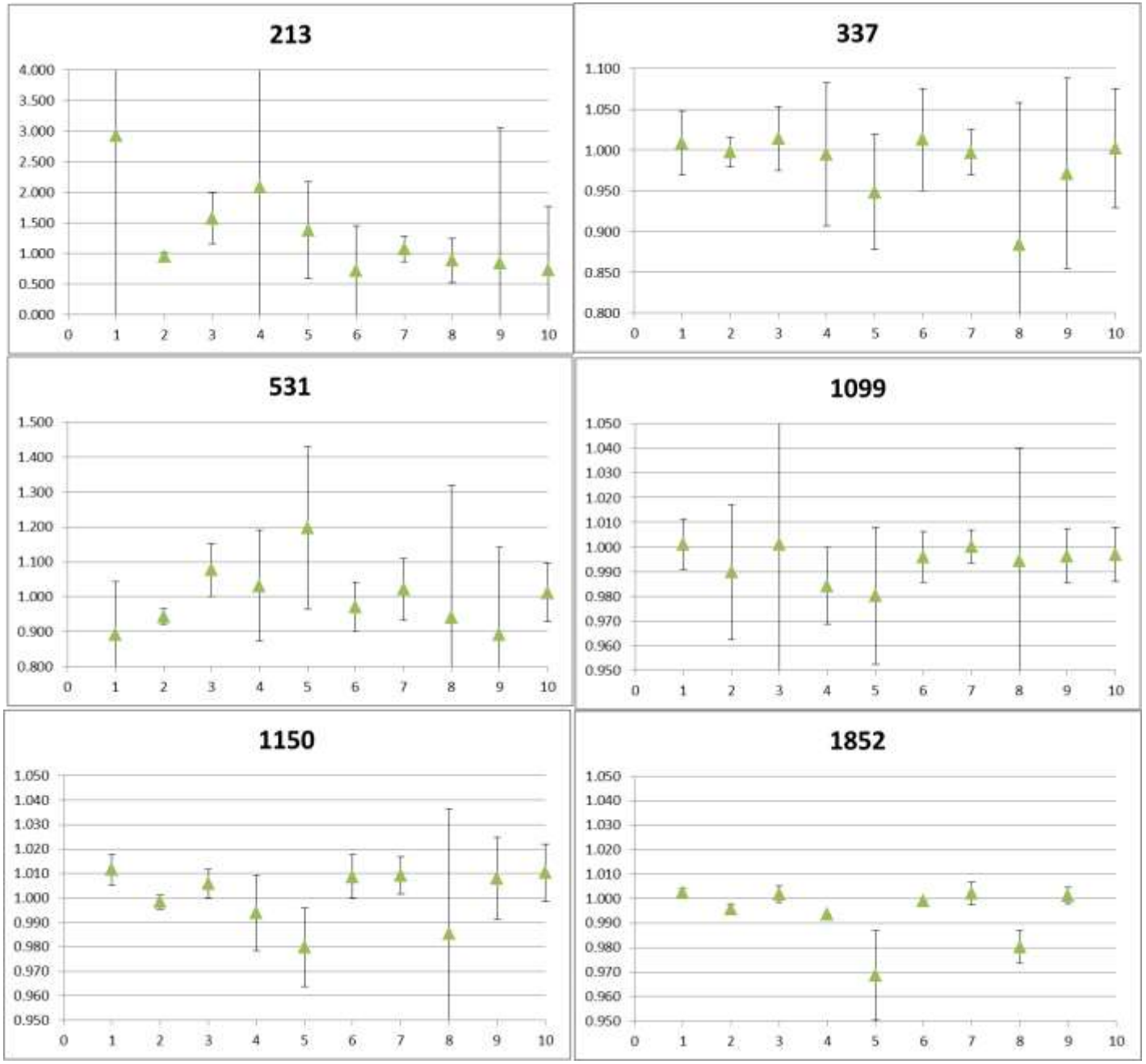




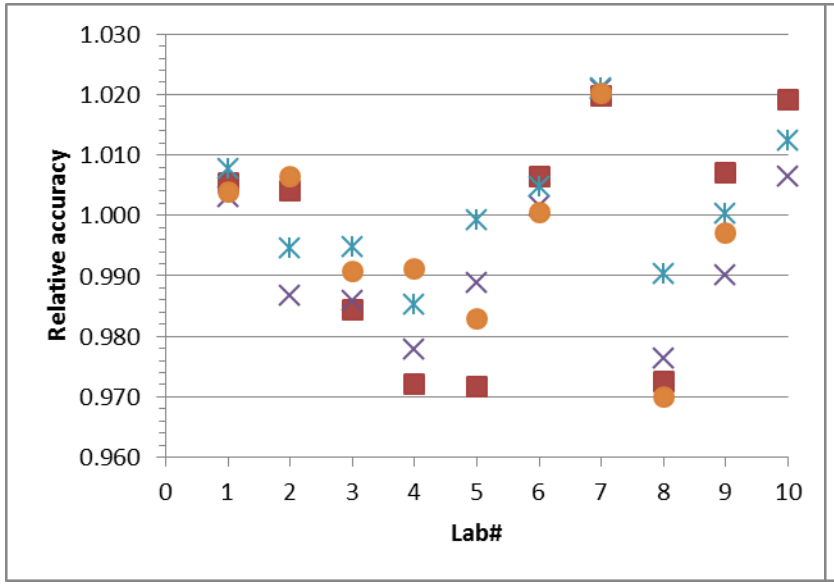


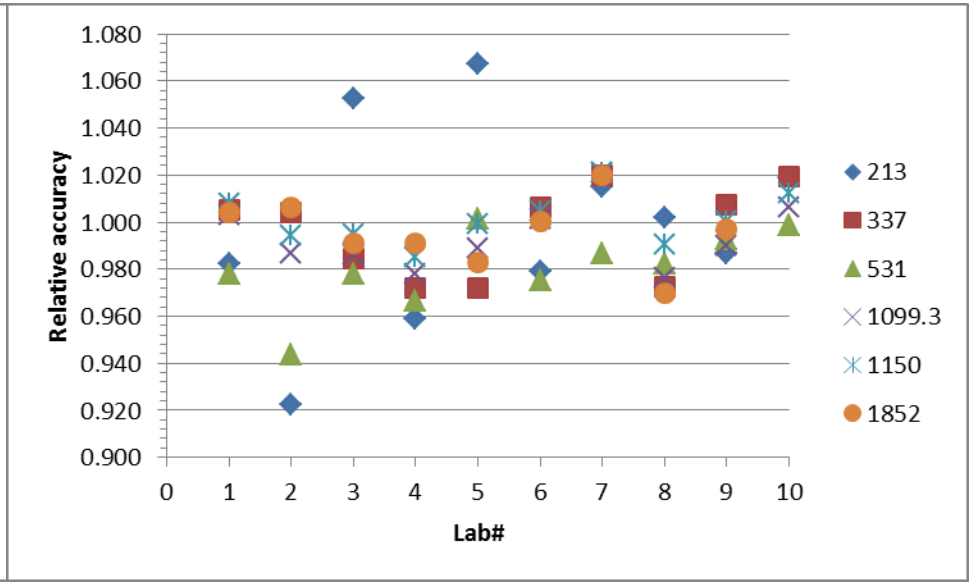


207Pb/206Pb age relative accuracy
(uncertainties are 1SD)

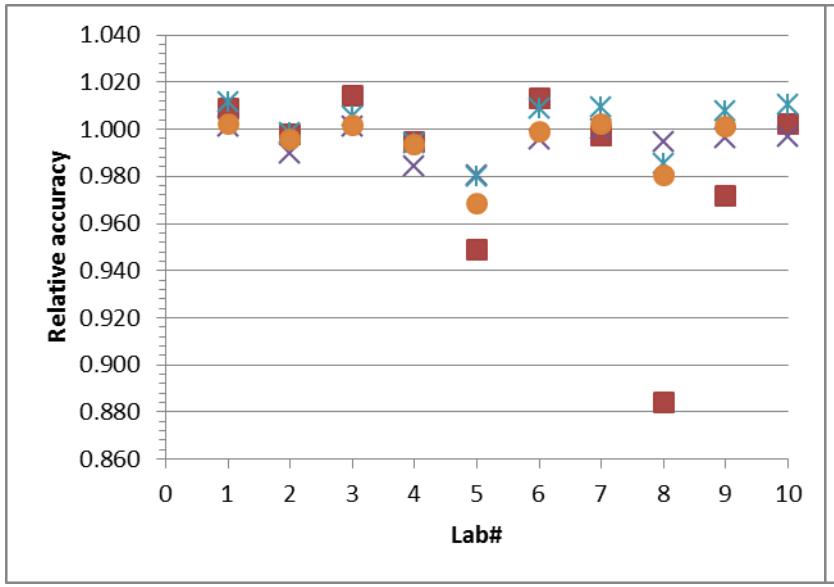


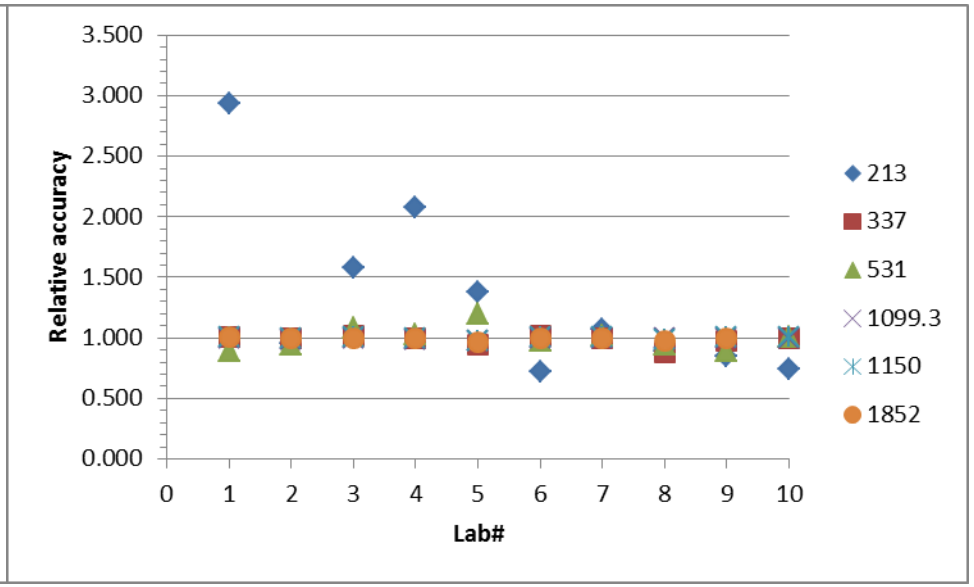
206Pb/238U age

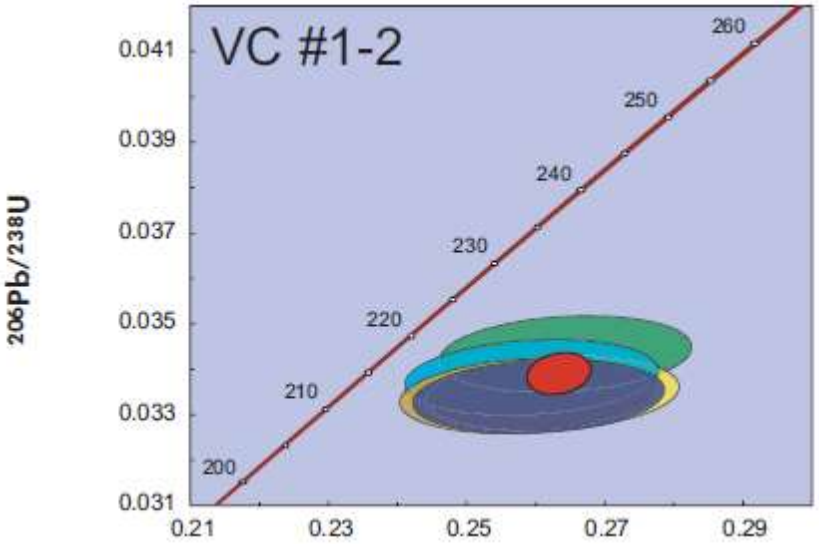


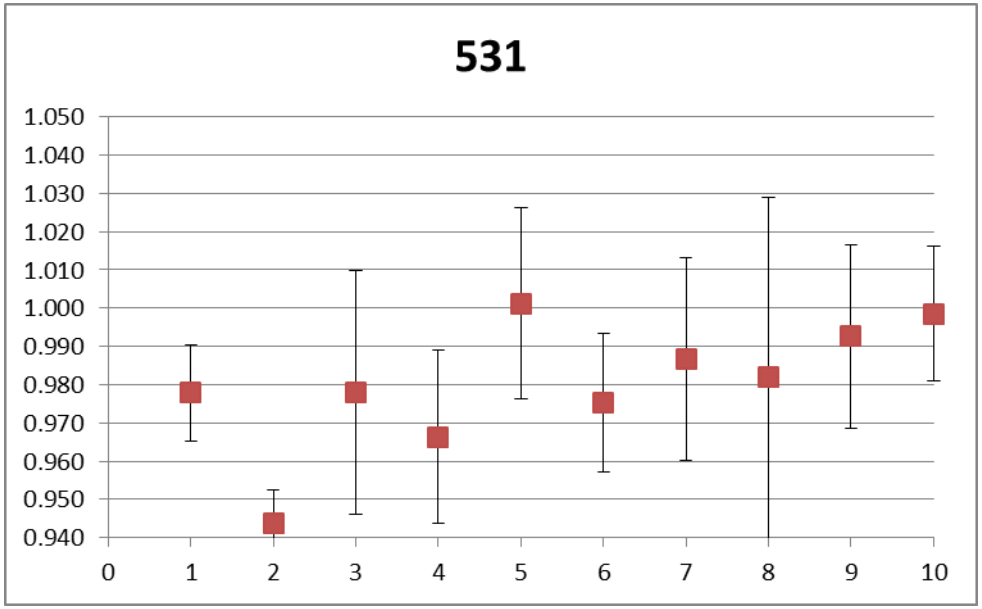


207Pb/206Pb age



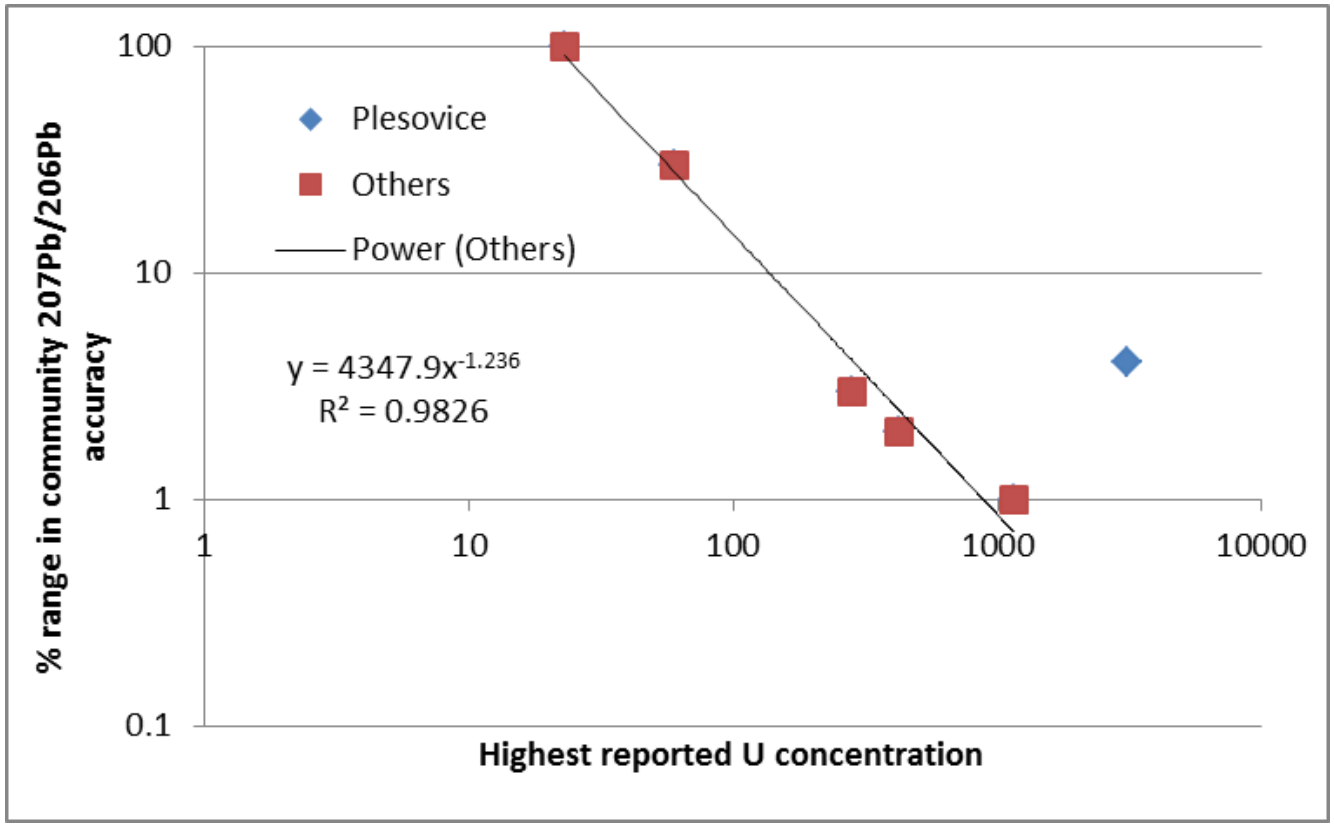



VC #1-2
206Pb/238U
0.041
0.039
0.037
0.035
0.033
0.031
0.21
0.23
0.25
0.27
0.29
200
210
220
230
240
250
260

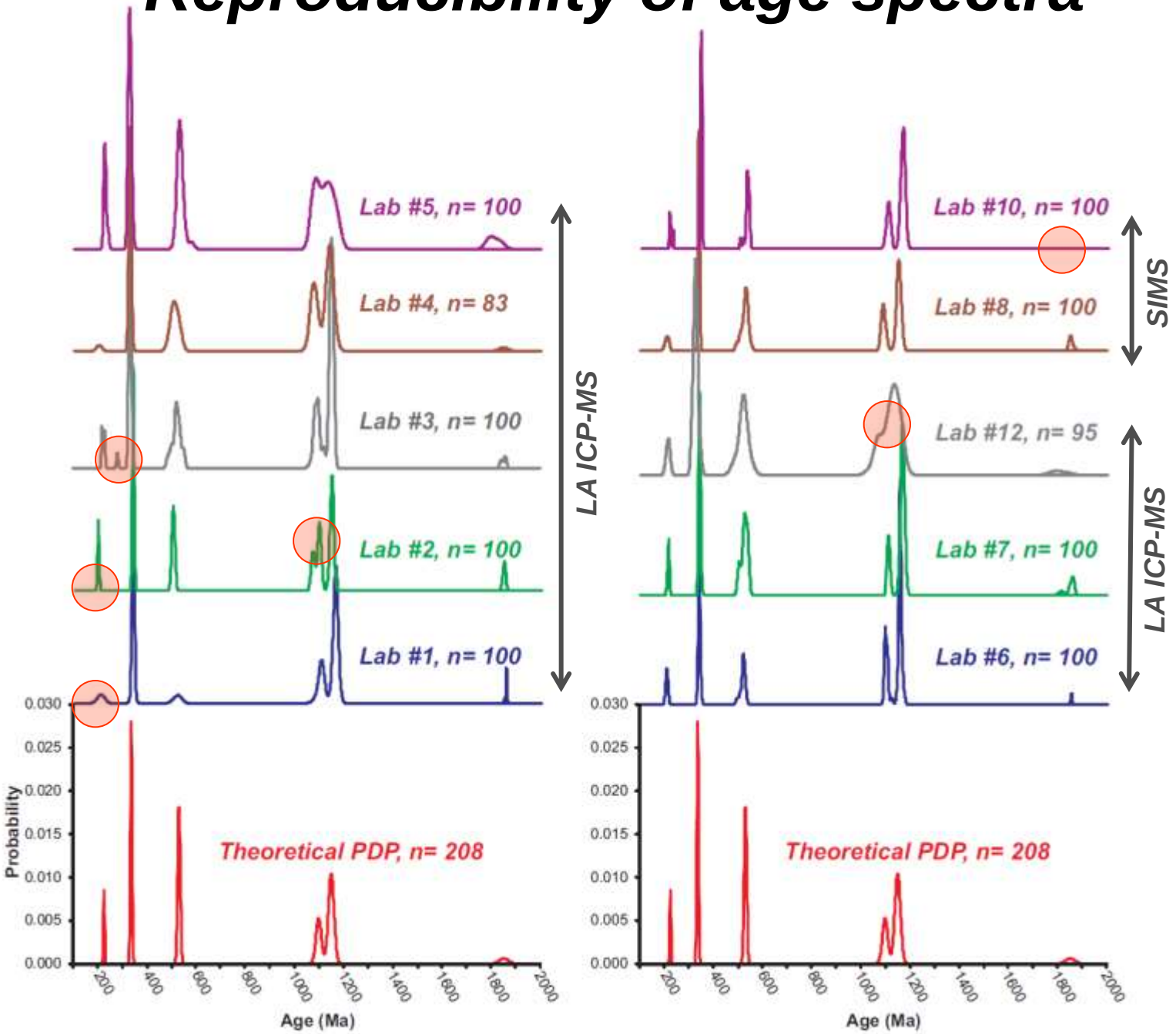

531
1.050
1.040
1.030
1.020
1.010
1.000
0.990
0.980
0.970
0.960
0.950
0.940
0
1
2
3
4
5
6
7
8
9
10

	Pb/U				Without 226 & 531	
	Lab#	**average accuracy**	**2SD%**		**average accuracy**	**2SD%**
	1	0.997	2.6		1.005	0.4
	2	0.976	7.1		0.998	1.8
	3	0.998	5.5		0.989	1.0
	4	0.975	2.4		0.982	1.7
	5	1.002	6.8		0.986	2.3
	6	0.995	2.7		1.003	0.5
	7	1.014	2.7		1.020	0.1
	8	0.982	2.5		0.977	1.8
	9	0.996	1.5		0.999	1.4
	10	1.011	1.7		1.013	1.3
average accuracy		0.995	3.6		0.997	1.2
	2SD%	2.7			2.8	
	Pb/Pb				**Without 226 & 531**	
	Lab#	**average accuracy**	**2SD%**		**average accuracy**	**2SD%**
	1	1.308	121.9		1.006	1.0
	2	0.980	4.9		0.995	0.8
	3	1.113	41.2		1.006	1.2
	4	1.180	74.9		0.992	1.0
	5	1.076	32.6		0.969	3.1
	6	0.951	24.3		1.004	1.6
	7	1.018	5.9		1.002	1.0
	8	0.946	10.5		0.961	10.7
	9	0.952	14.2		0.994	3.2
	10	0.952	25.2		1.003	1.3
average accuracy		1.047	35.6		0.993	2.5
	2SD%	23.3			3.2	

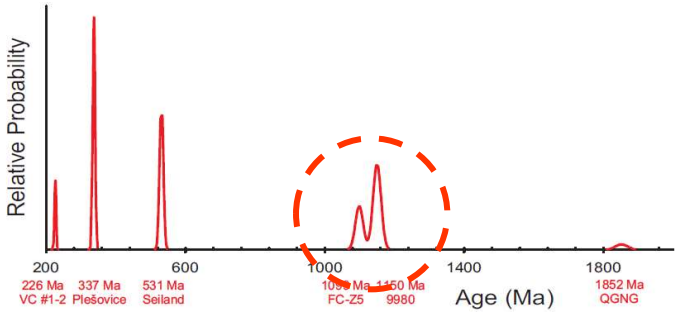
	ppm U
VC #1-2	17 - 23
Plešovice	465 - 3084
Seiland	7 - 60
FC-Z5	220 - 426
9980	231 - 281
QGNG	35 - 1151



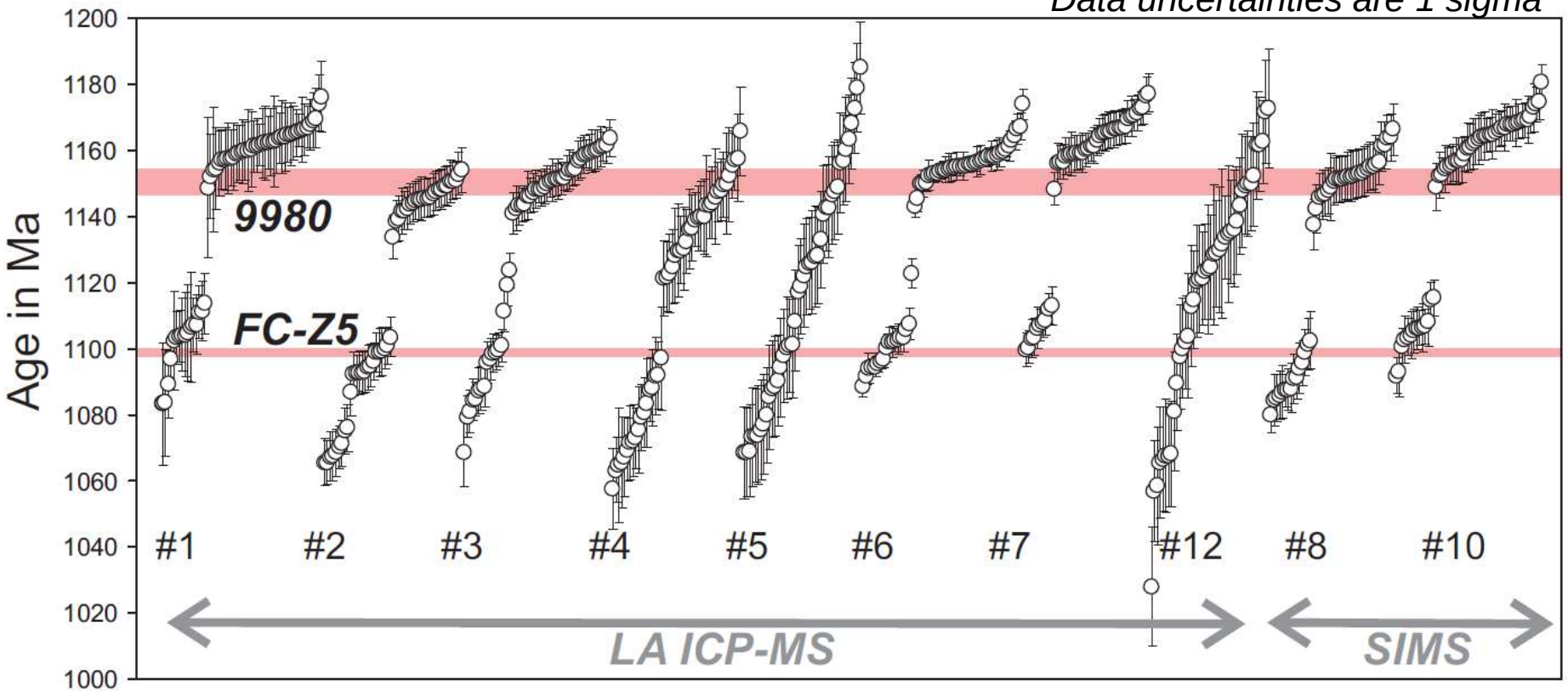
Reproducibility of age spectra



U-Pb age resolution



Data uncertainties are 1 sigma



Note: U-Pb concordia ages, some labs filtered their data,
different instruments (SC *vs.* MC), reference TIMS ages are ±2σ

Ablation parameters used

Lab #	Laser radiation λ	Laser fluence	Repetition rate	Spot size	Ablation cell	Ablation time	ICP-MS	Primary reference	Processing package	Common Pb
	nm	$J.cm^{-2}$	Hz	μm	volume	s		zircon		correction
1	193	?	7	30	2 volume	15	MC	Sri Lanka	In-house spreadsheet	Yes
2	193	1.5	5.5	23	2 volume	21	SC	GJ1	In-house spreadsheet	When appropriate
3	213	8	5	40	LFC	120	Q	GJ1	Glitter	Yes
4	193	4	8	10 (40x40 raster)	25 cm^3	160	SC	?	LamDate	No
5	193	12	5	20	20 cm^3	60	SC	91500	?	No
6	193	<5	5	55	2 volume	60	Q	91500	Iolite	No
7	193	2	5	35	3 cm^3	30	SC	Plešovice	In-house spreadsheet	No
8	193	7	5	19 (line raster)	2 volume	110	SC	Plešovice	LamDate	No

LFC - large format cell, MC - multi-collector ICP-MS, SC - single collector magnetic sector ICP-MS, Q - quadrupole ICP-MS

Sources of error/bias

- Operator error
- Variable reference values
- Instrumentation hardware – lasers, cell geometries, mass spec type (Q-SC-MC) not a fundamental limitation to accuracy just uncertainty.
- Instrument characterisation – detector linearity & deadtime, (dwell times?).
- Software processing parameters – LIEF correction method, reference values, data fitting models, underestimation of uncertainty, common-Pb correction
- Alpha dose of sample materials (Allen & Campbell 2012)? – this would lead to a range of results for each lab and not all labs showed this (4 labs <1% 2SD).

Other conclusions

- Uncertainties underestimated in both Pb/Pb and U/Pb at highest U concentrations
- **Current community performance ca. 3% 2SD Pb/U & Pb/Pb**
- **<0.5% 2SD & <1% 2SD achievable targets for Pb/U and Pb/Pb** respectively.
- Each lab to identify their offset problems and repeat the exercise in a 1-2yrs time? Then publish results highlighting (not per lab!) the combined measures that were required to be implemented to reduce the systematic offsets?