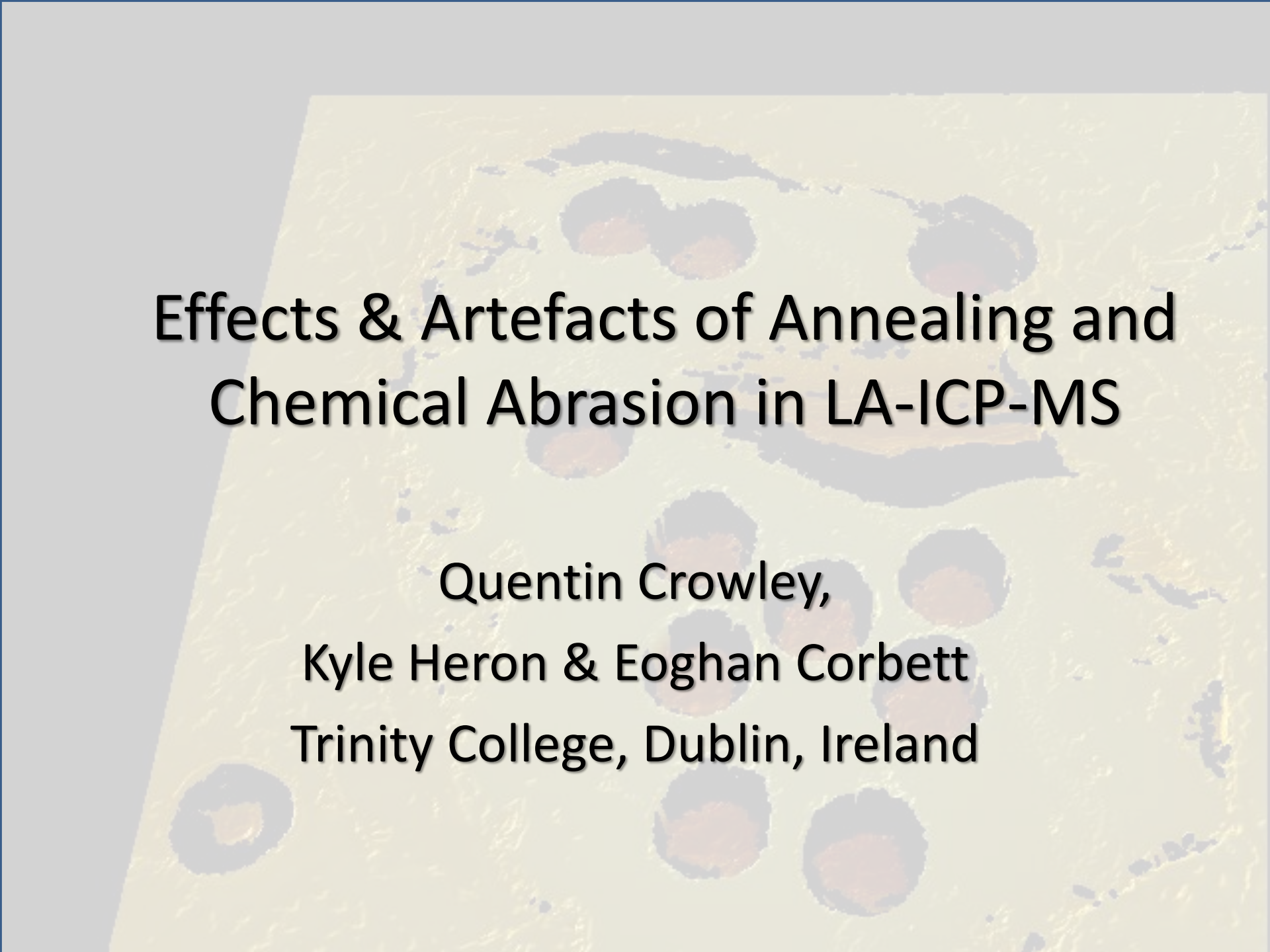




Effects & Artefacts of Annealing and Chemical Abrasion in LA-ICP-MS

Quentin Crowley,
Kyle Heron & Eoghan Corbett
Trinity College, Dublin, Ireland

Article

Chemical Abrasion Applied to LA-ICP-MS U–Pb Zircon Geochronology

Quentin G. Crowley ^{1,*}, Kyle Heron ¹, Nancy Riggs ², Balz Kamber ¹, David Chew ¹,
Brian McConnell ³ and Keith Benn ⁴

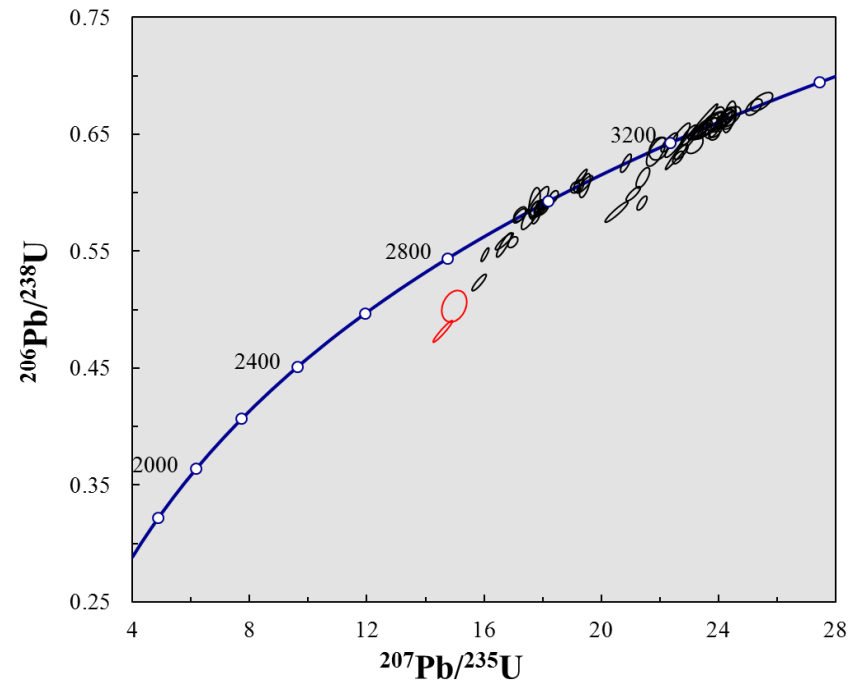
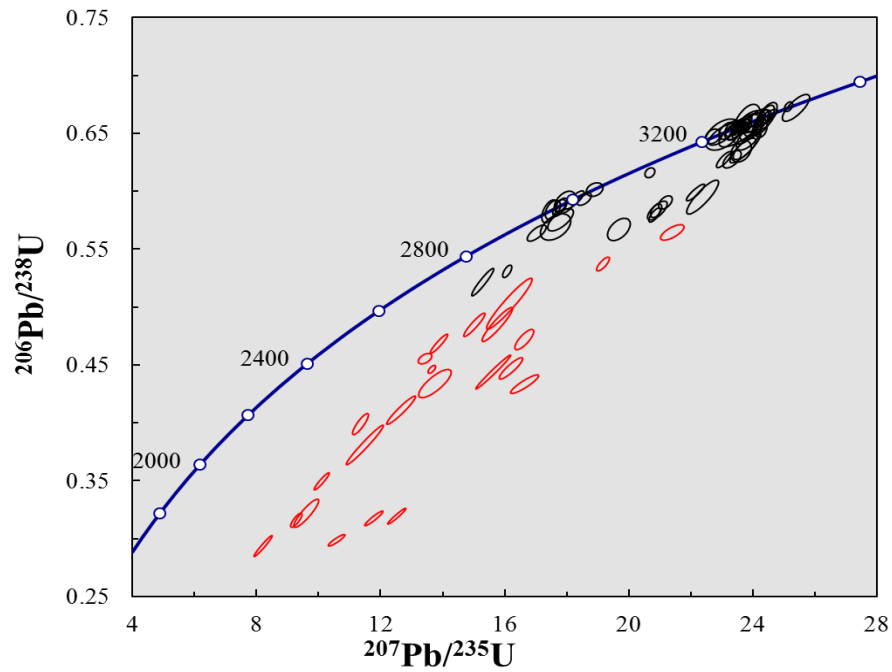
¹ Department of Geology, School of Natural Sciences, Trinity College, Dublin 2, Ireland;
E-Mails: heronky@tcd.ie (K.H.); kamberbs@tcd.ie (B.K.); chewd@tcd.ie (D.C.)

² School of Earth Sciences and Environmental Sustainability, Northern Arizona University, Flagstaff,
AZ 86011, USA; E-Mail: nancy.riggs@nau.edu

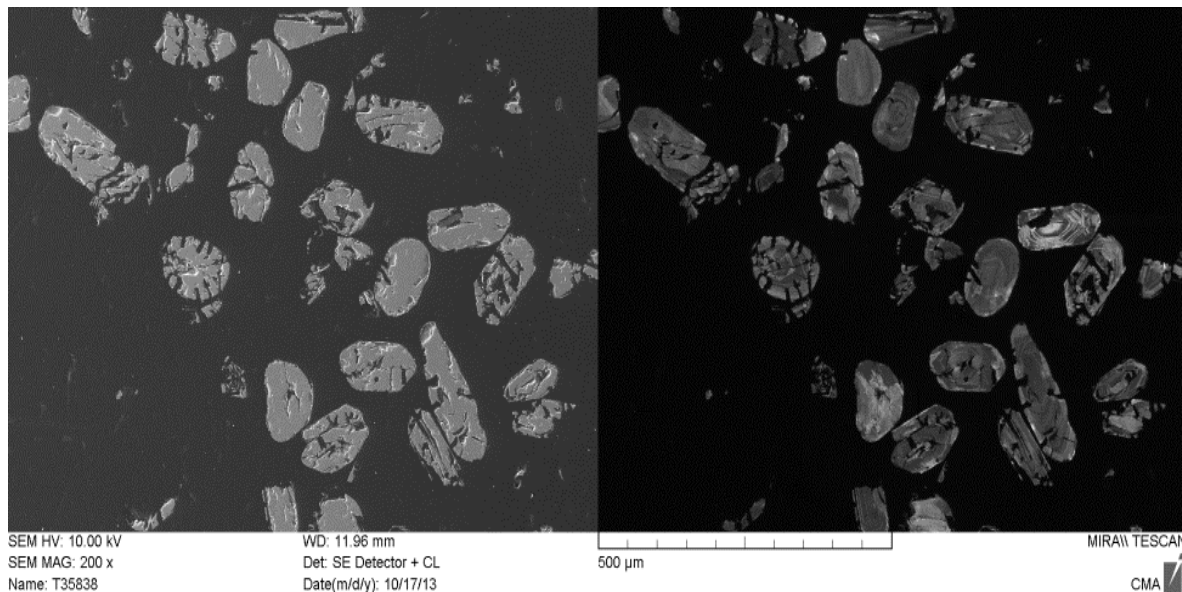
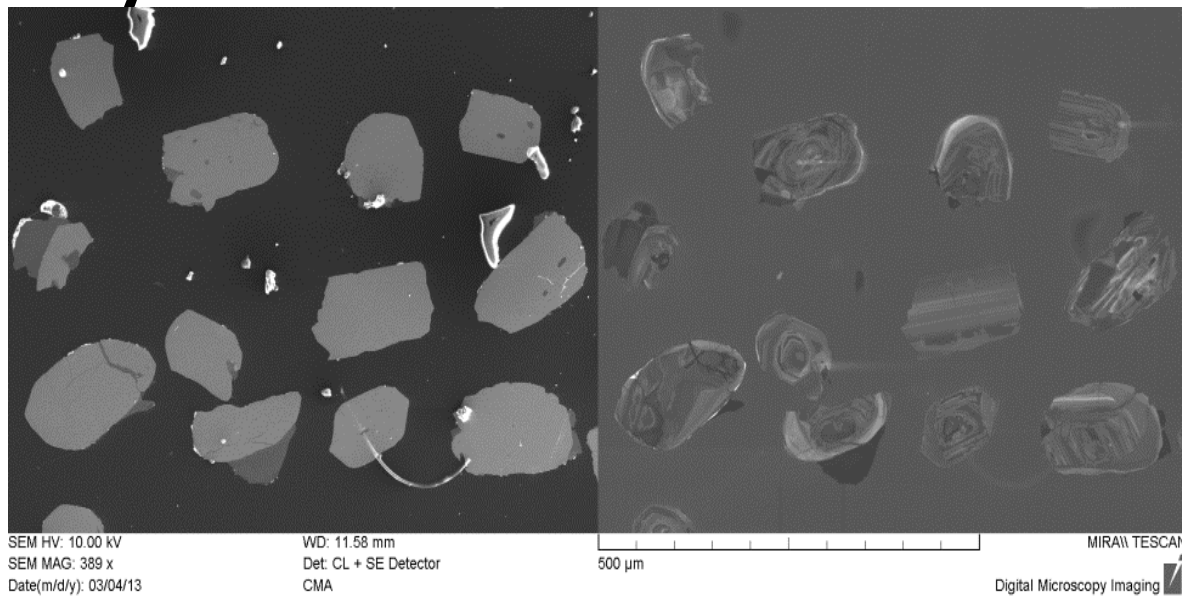
³ Geological Survey of Ireland, Beggars Bush, Dublin 4, Ireland; E-Mail: brian.mcconnell@gsi.ie

⁴ Tasiast Mauritanie Limited SA, ZRA 741, BP 5051, Nouakchott, Mauritania, West Africa;
E-Mail: keith.benn@kinross.com

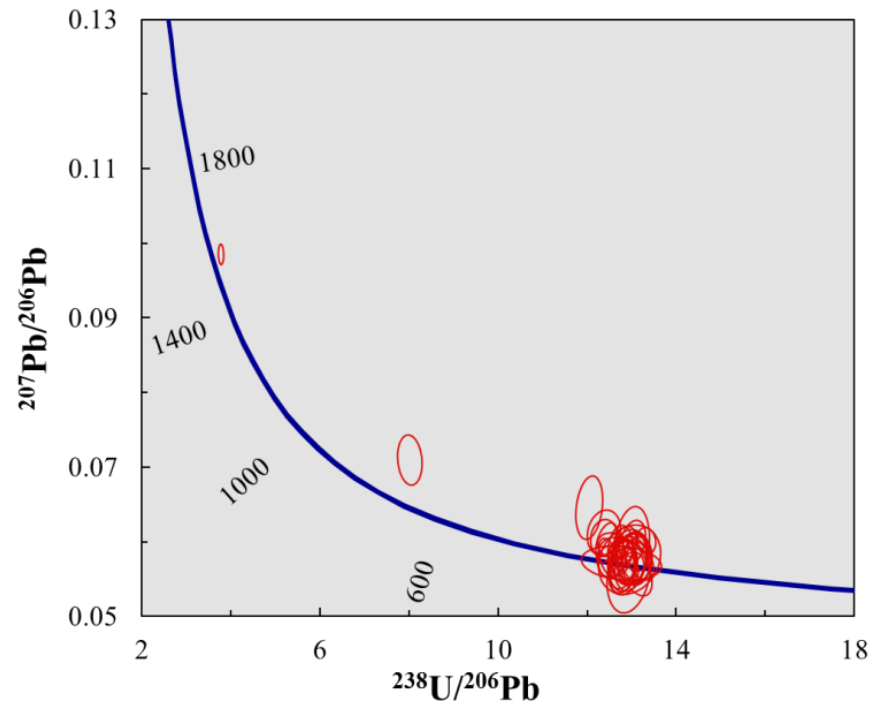
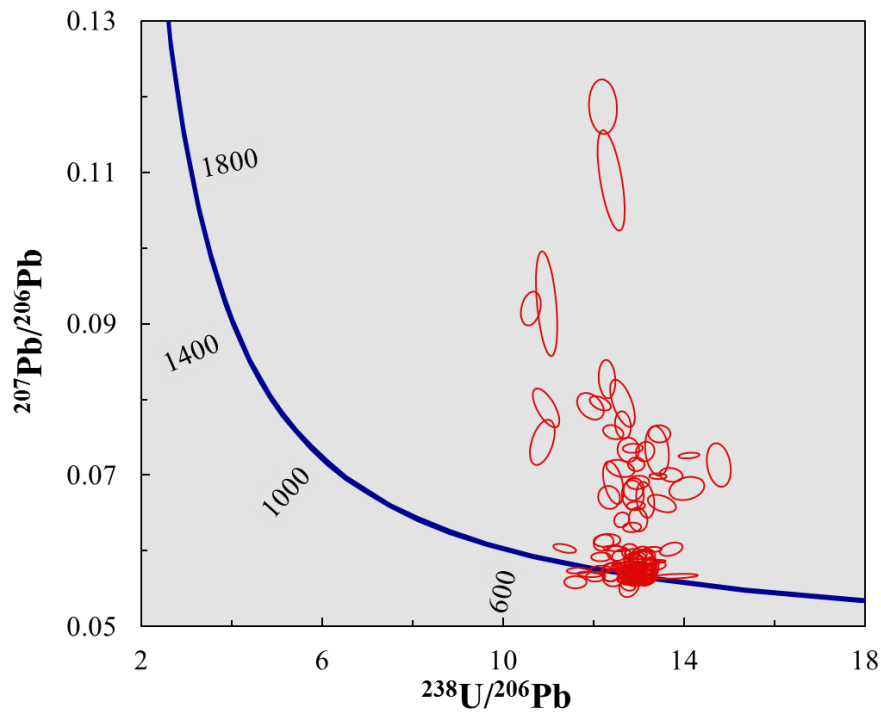
Why use A-CA for LA-ICP-MS?



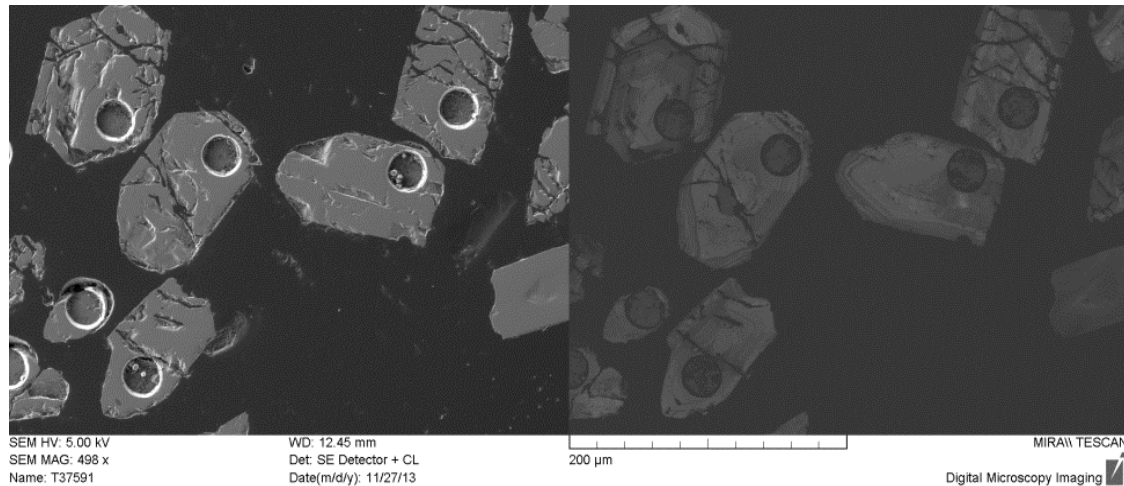
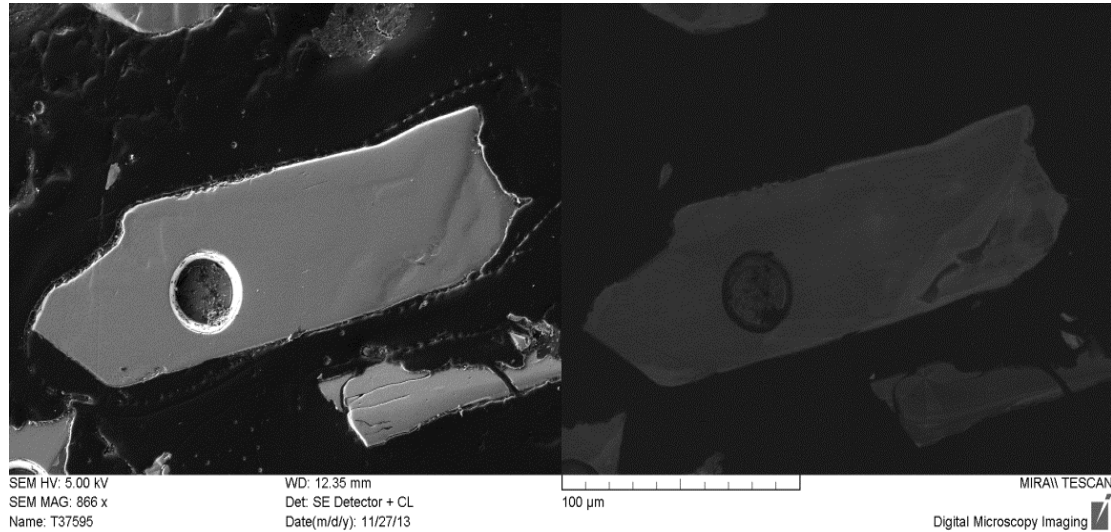
Physical Effect on Zircons



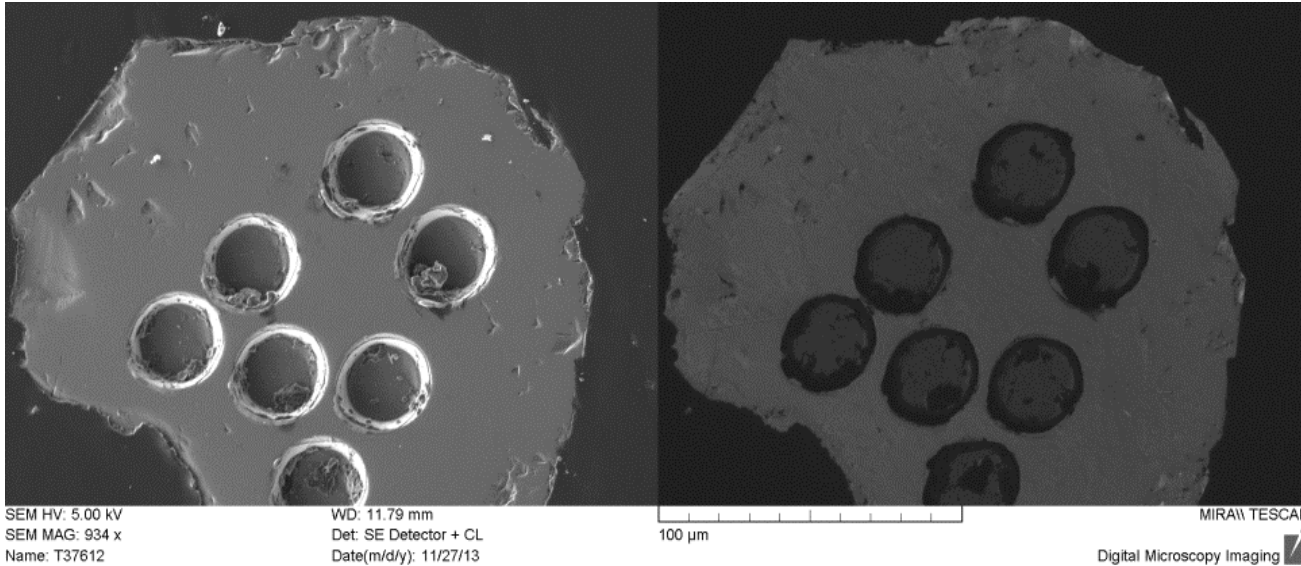
Why use A-CA for LA-ICP-MS?



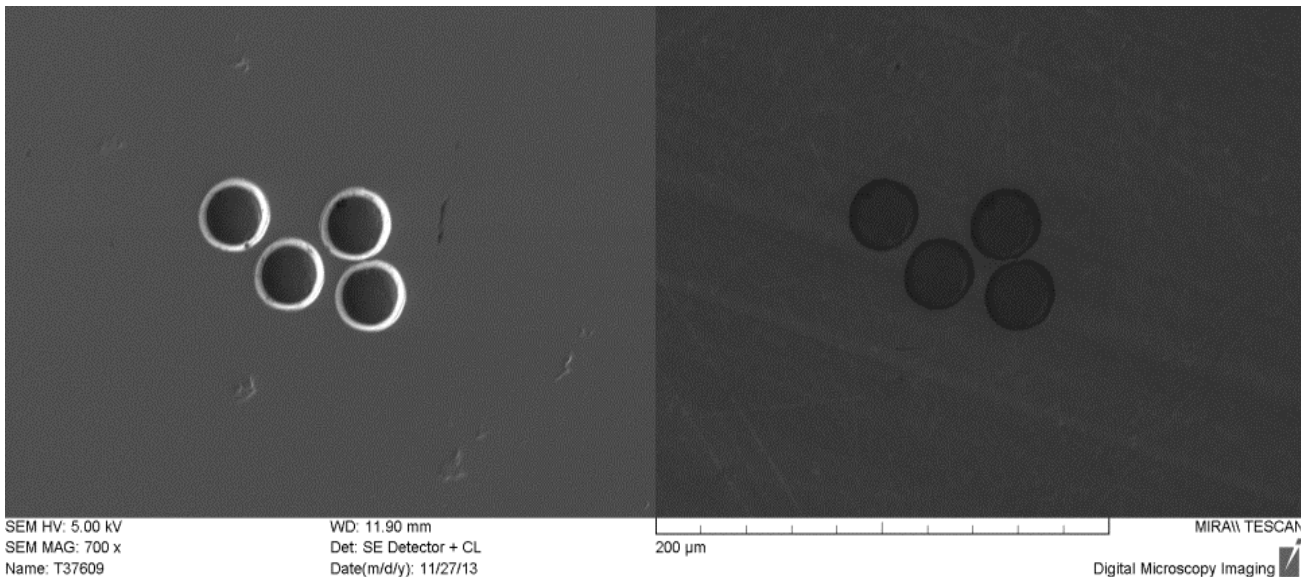
Physical Effect on Zircons



Physical Effect on Zircons



91500

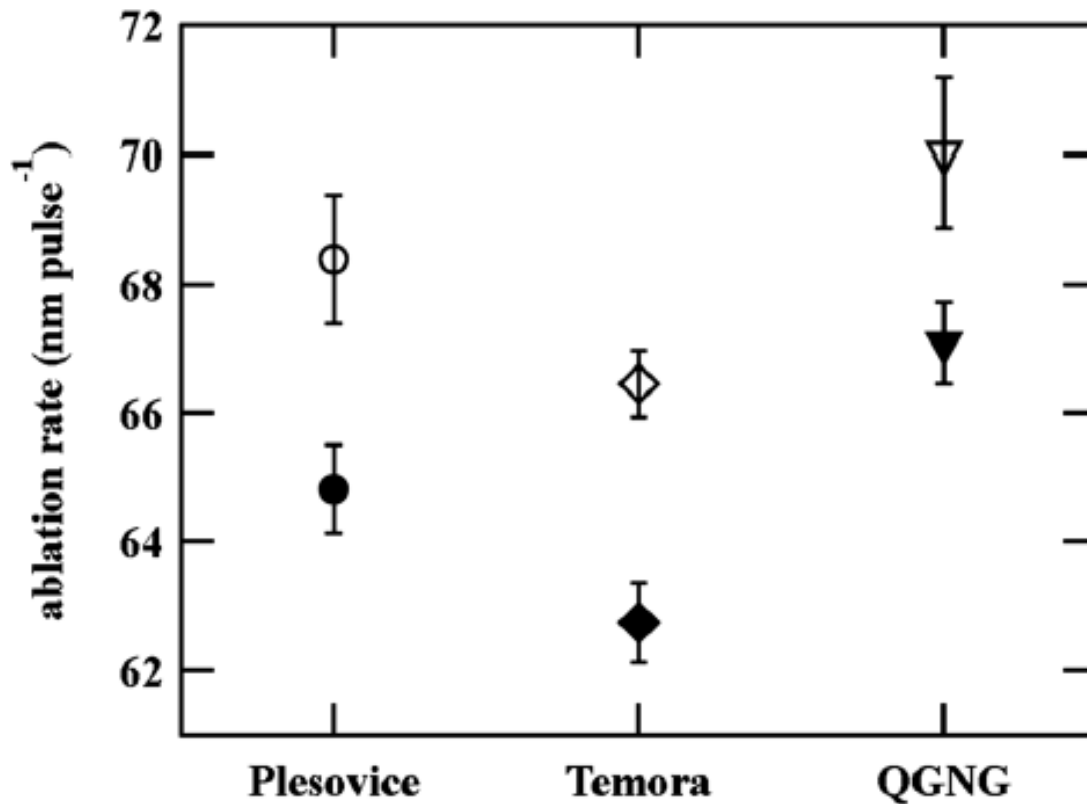


Penglai

Variation in Ablation Rate (Non-Annealed & Annealed)

E. Marillo-Sialer *et al.*

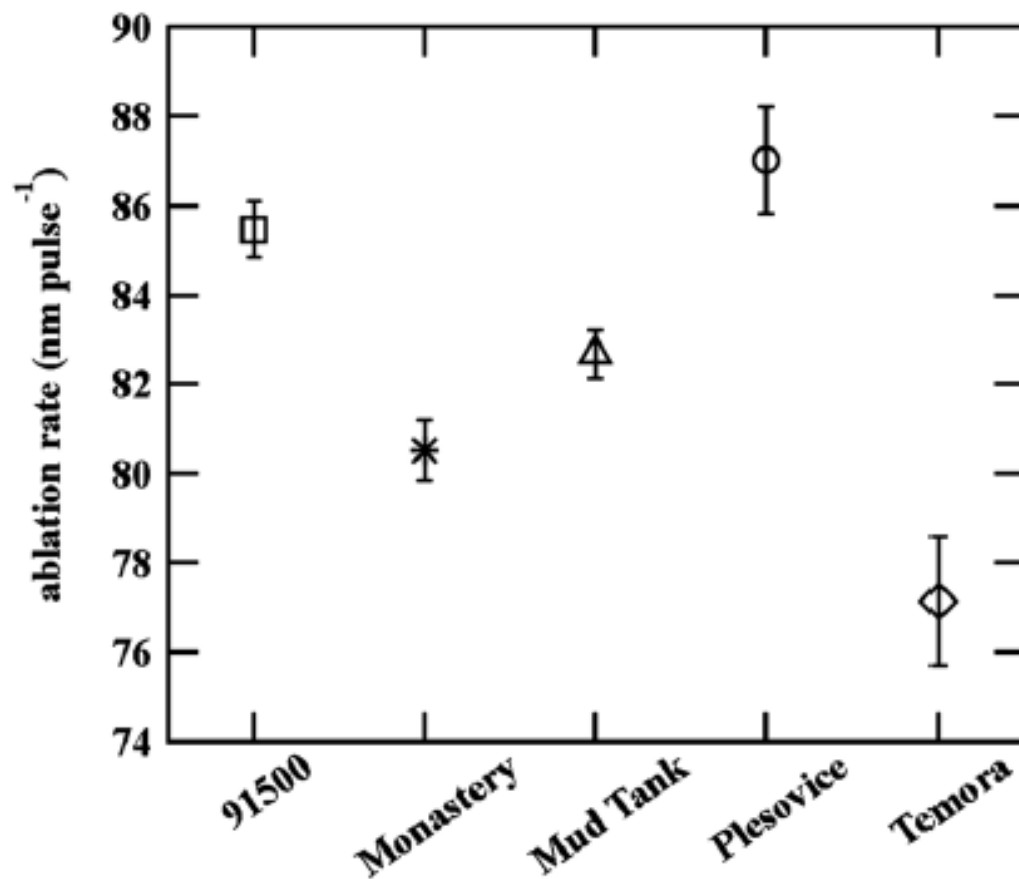
The zircon 'matrix effect': evidence for an ablation rate control on the accuracy of U-Pb age determinations by LA-ICP-MS



Variation in Ablation Rate Non-Annealed Zircon

E. Marillo-Sialer *et al.*

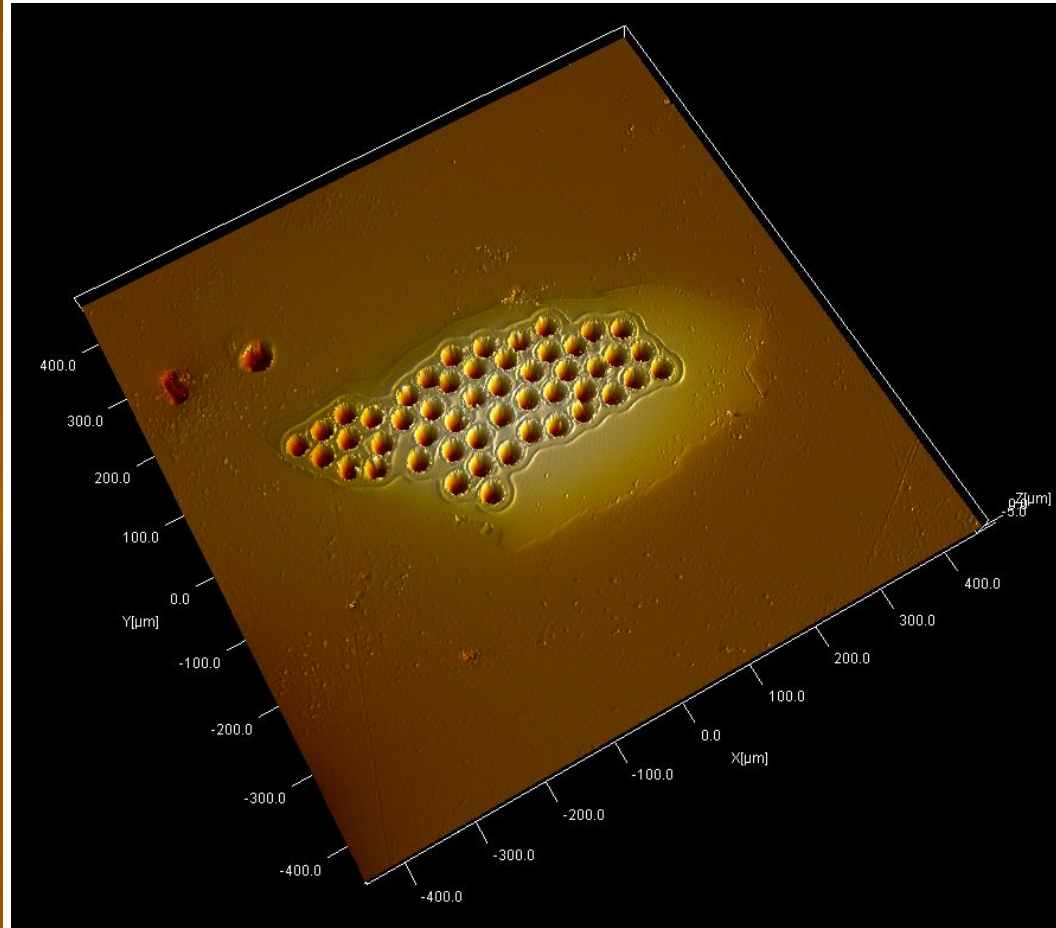
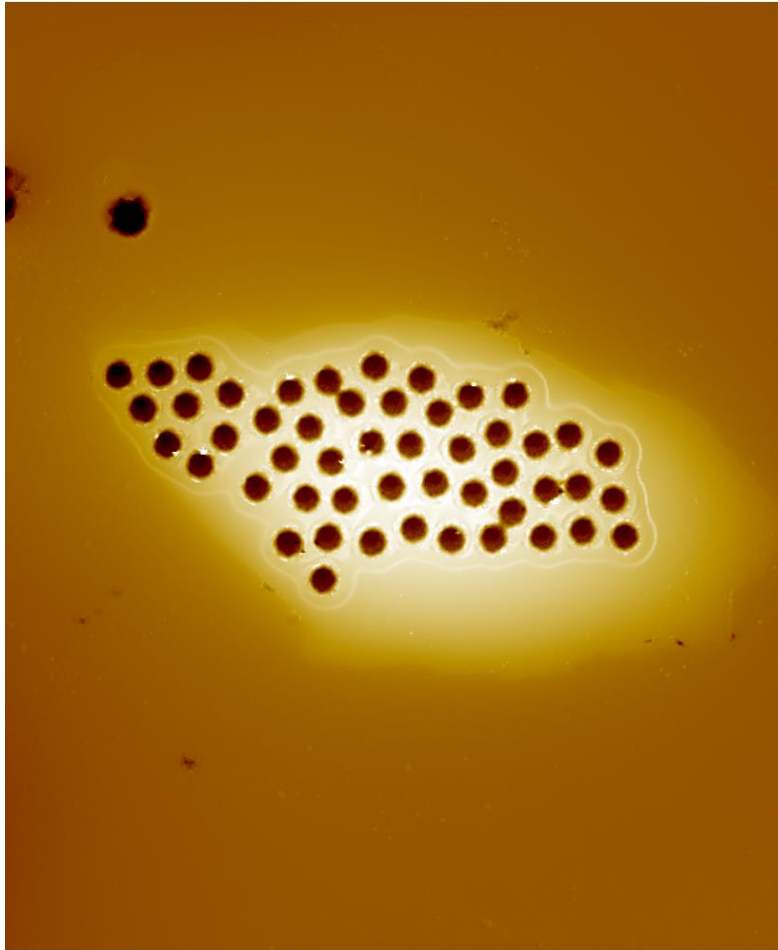
The zircon 'matrix effect': evidence for an ablation rate control on the accuracy of U-Pb age determinations by LA-ICP-MS



Analytical Set-Up

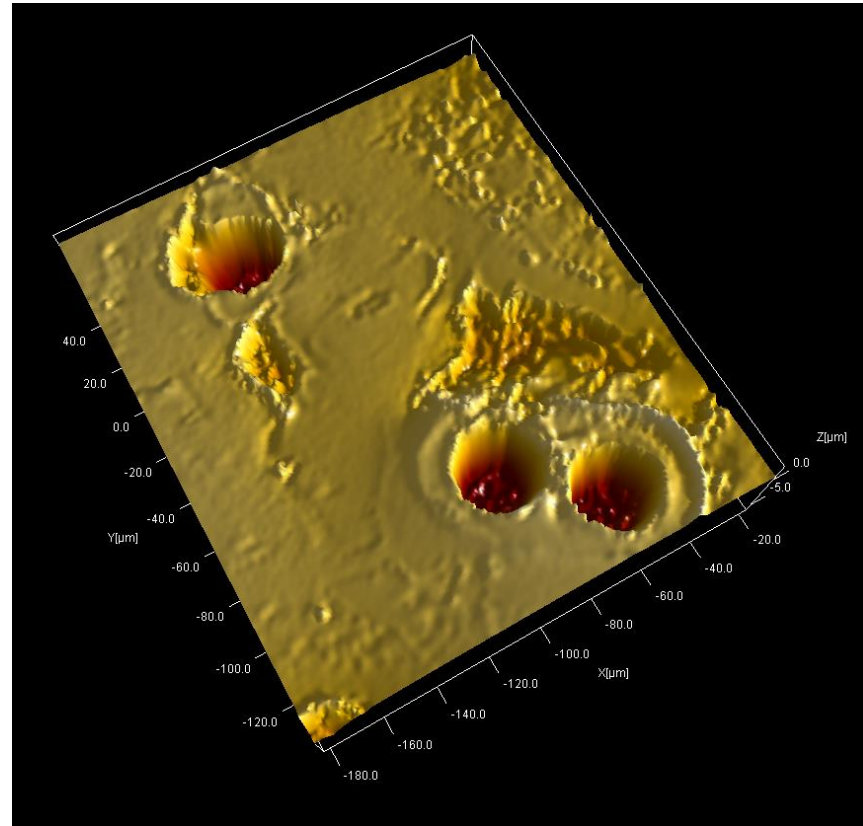
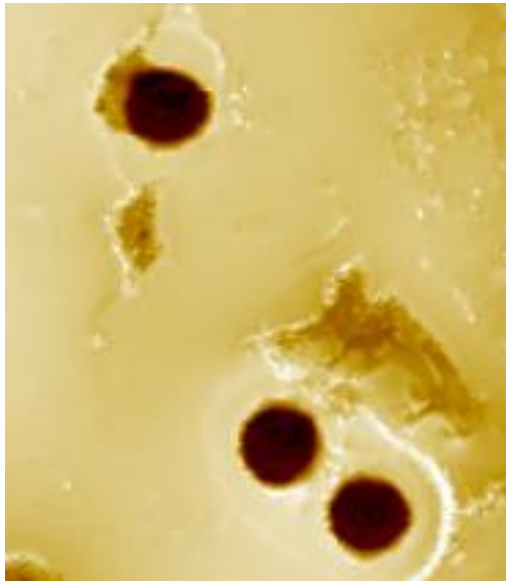
ICP Instrument model	
Plasma RF power (W)	Thermo-Scientific iCAP-Qs (quadrupole)
Plasma gas flow (lit/m)	0.7
LA Instrument Model	Photon Machines Analyte 193
Laser	ATLEX-SI 193 nm ArF excimer
Fluence (J/cm ²)	3.9
Repetition Rate (Hz)	4
Delay between analyses (s)	20
Ablation duration (s)	40
Carrier gas flow (lit/m)	0.65 (He), 0.006 (N ₂)
Spot diameter (μm)	30

Mud Tank Zircon Non-Annealed



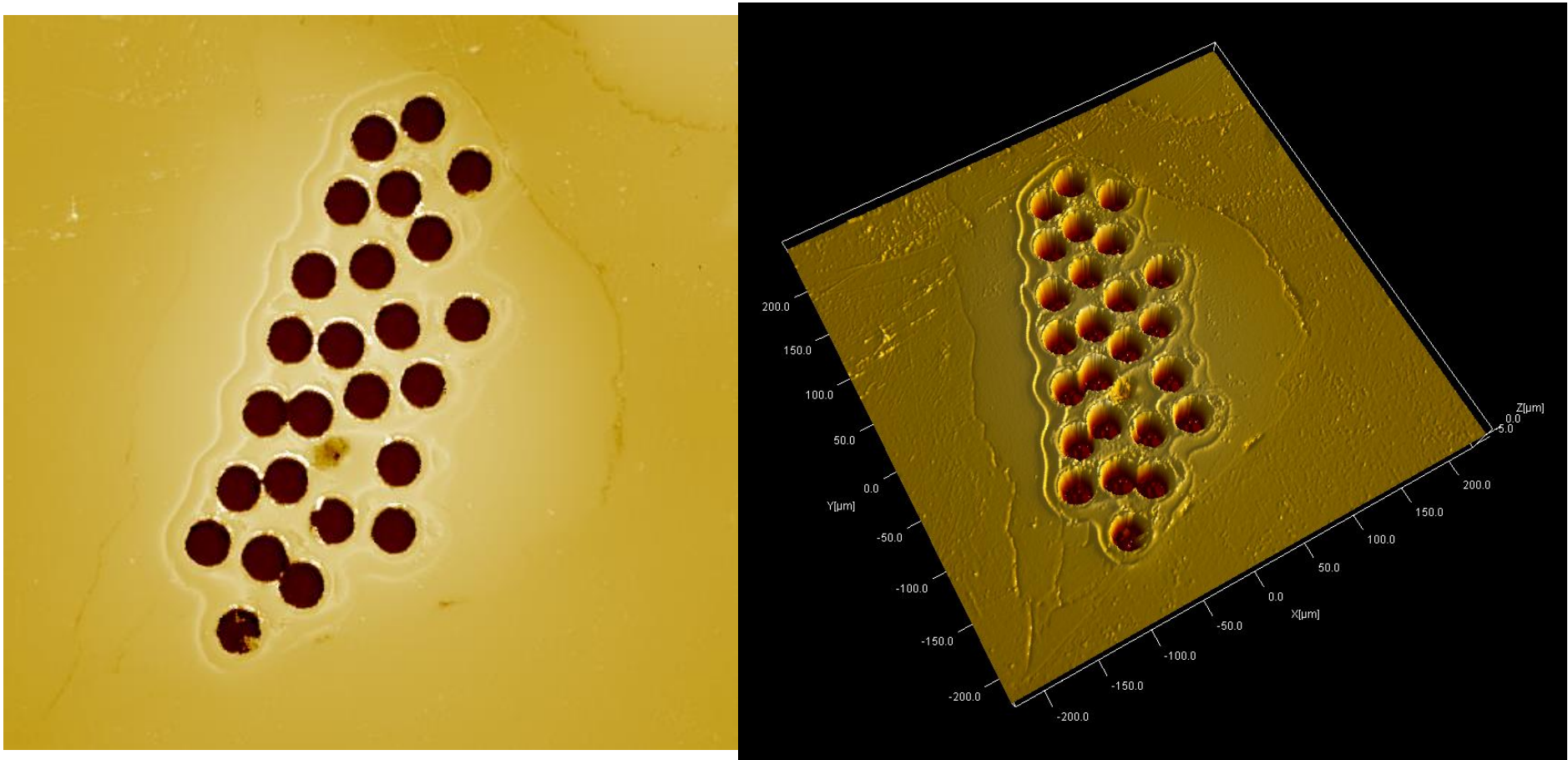
U-Pb age = 732 ± 5 Ma , U ppm = 6-35ppm (20-30ppm), Alpha Dose = $8.171\text{E}+13 \pm 6.7\text{E}+12$ [8.2%], N=47, Ablation rate = 22 nm/shot ($3.9\text{J}/\text{cm}^2$)

FCT Zircon Non-Annealed



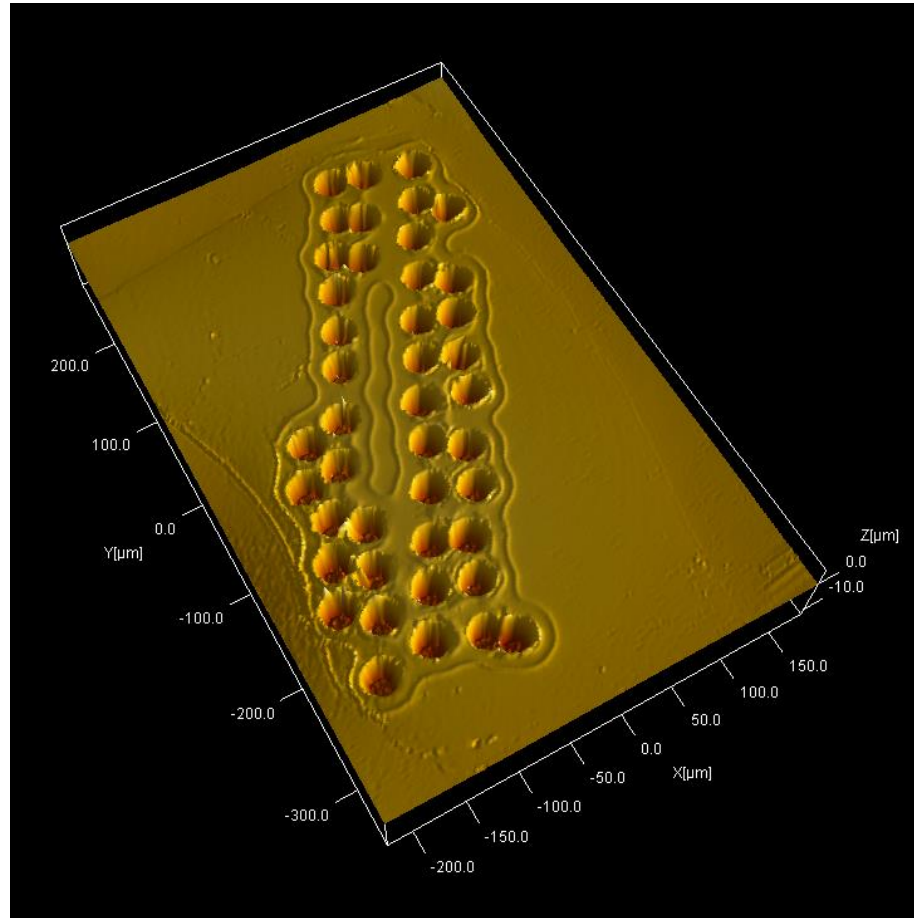
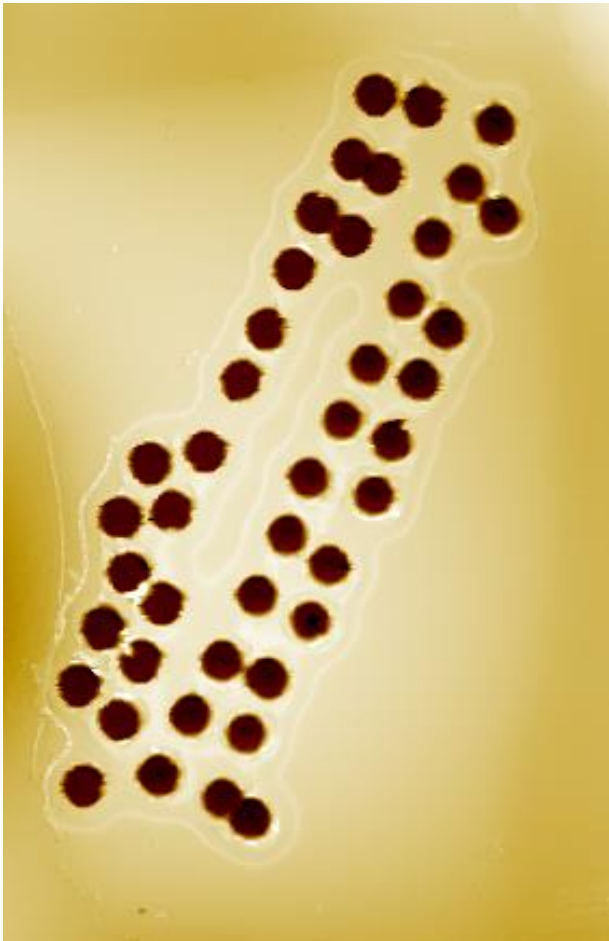
U-Pb age = 28.38 ± 0.5 Ma, Uppm = (400-800ppm), Alpha Dose = $5.019\text{E}+13 \pm 7.7\text{E}+12$ [15%]
N=25, pit depth = 4.48 ± 0.08 μ, Ablation rate = 25 nm / pulse

Penglai Zircon Annealed



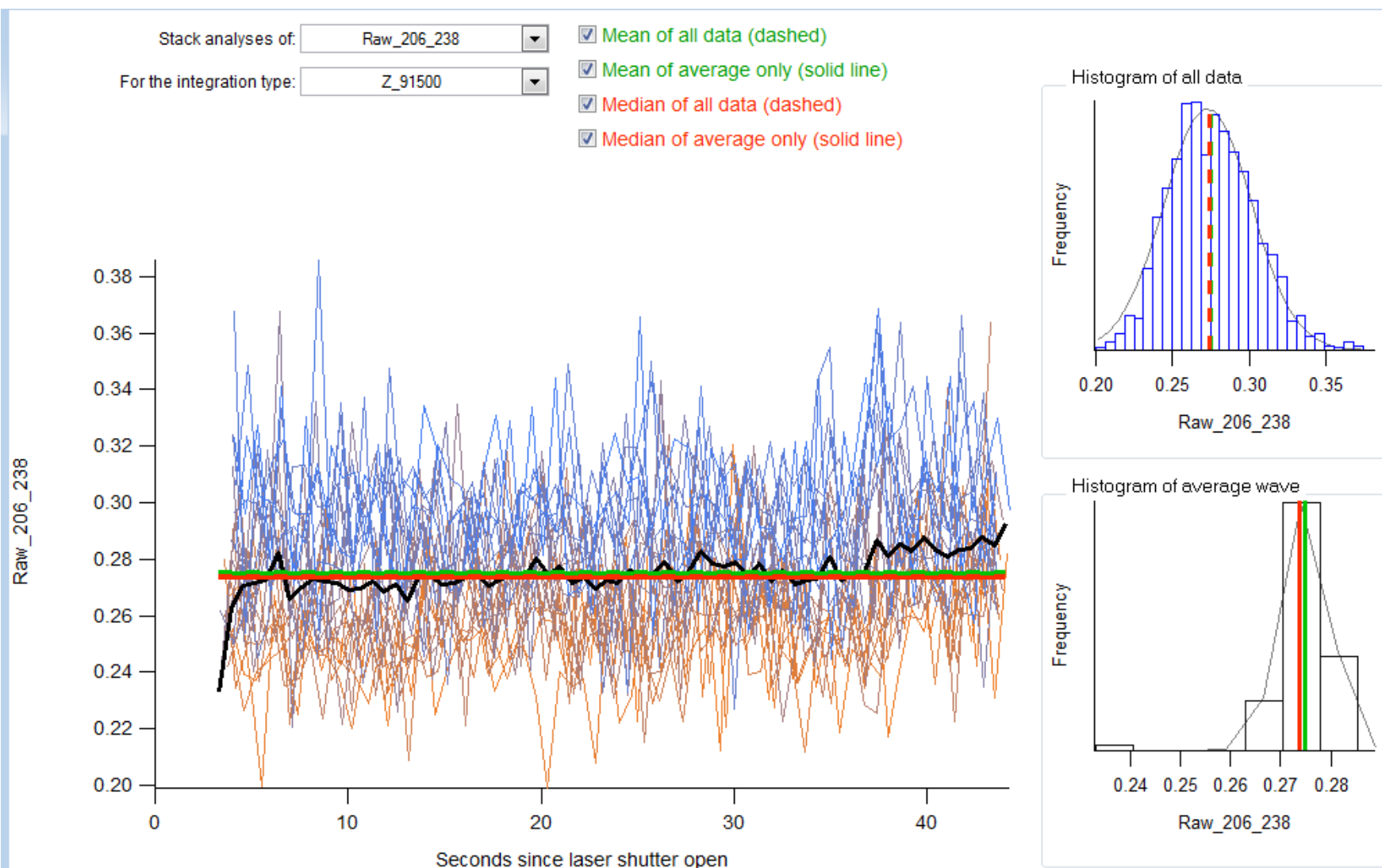
U-Pb age = 4.4 ± 0.1 Ma , Uppm = 70-280ppm, Alpha Dose = $2.789\text{E}+12 \pm 3.0\text{E}+11$ [11%]
N=25, pit depth = 4.8 ± 0.1 μ
Ablation rate = 27 nm / pulse

91500 Zircon Annealed



U-Pb age = 1062.4 ± 0.4 Ma , U ppm = 65-90, Alpha Dose = $3.3438\text{E}+14 \pm 1.7\text{E}+12$ [0.52%]
N=45, pit depth = $5.5 \pm 0.7\mu$, Ablation rate = 30 nm / pulse

91500 (Annealed) Raw $^{206}\text{Pb}/^{238}\text{U}$

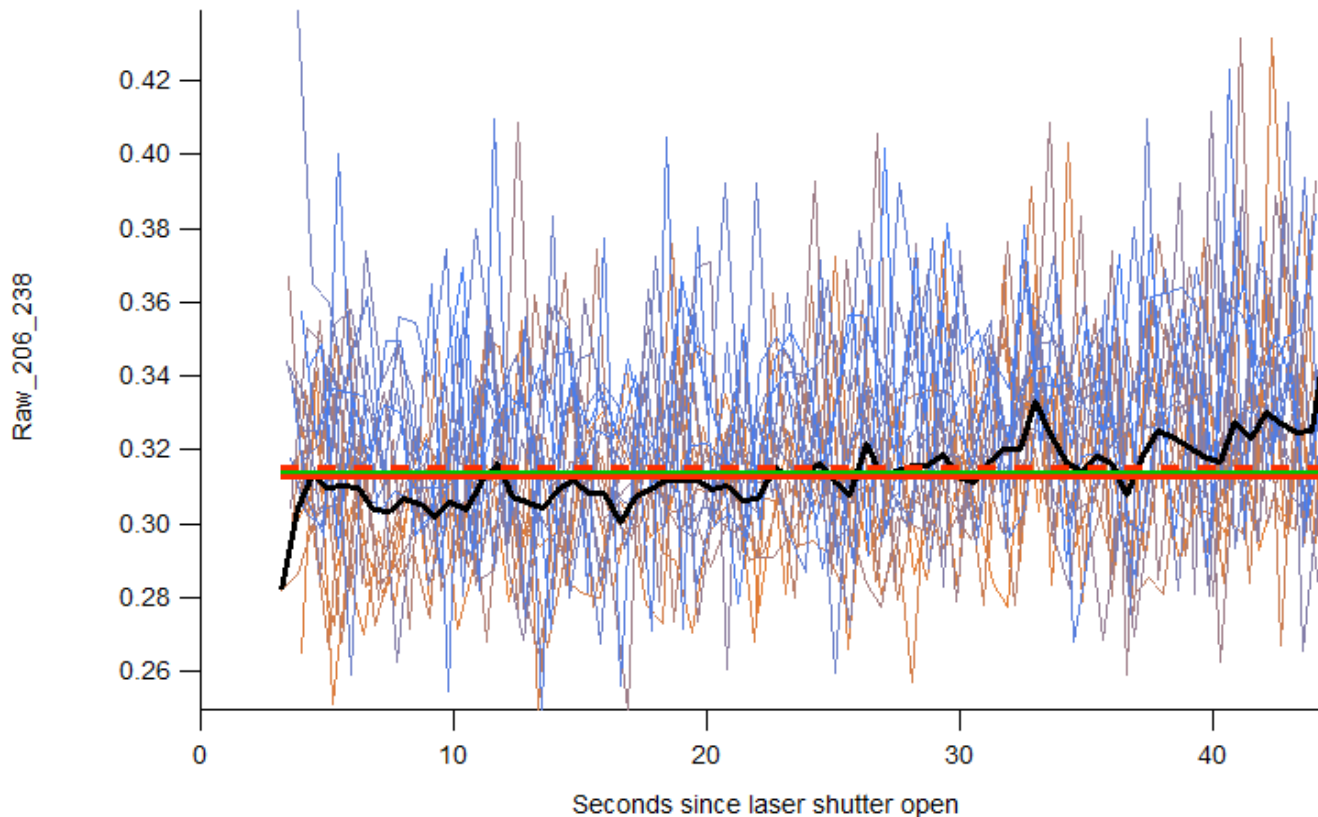


91500 (Non-Annealed) Raw $^{206}\text{Pb}/^{238}\text{U}$

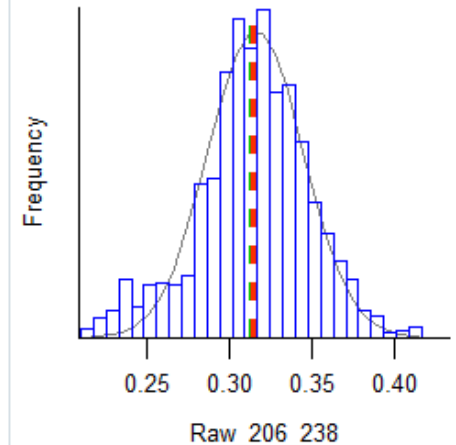
Stack analyses of: Raw_206_238

For the integration type: Z_91500

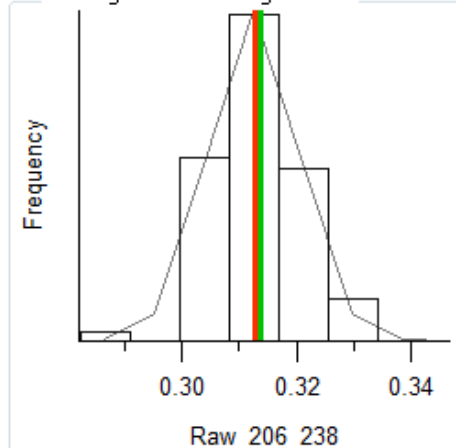
- ☒ Mean of all data (dashed)
- ☒ Mean of average only (solid line)
- ☒ Median of all data (dashed)
- ☒ Median of average only (solid line)



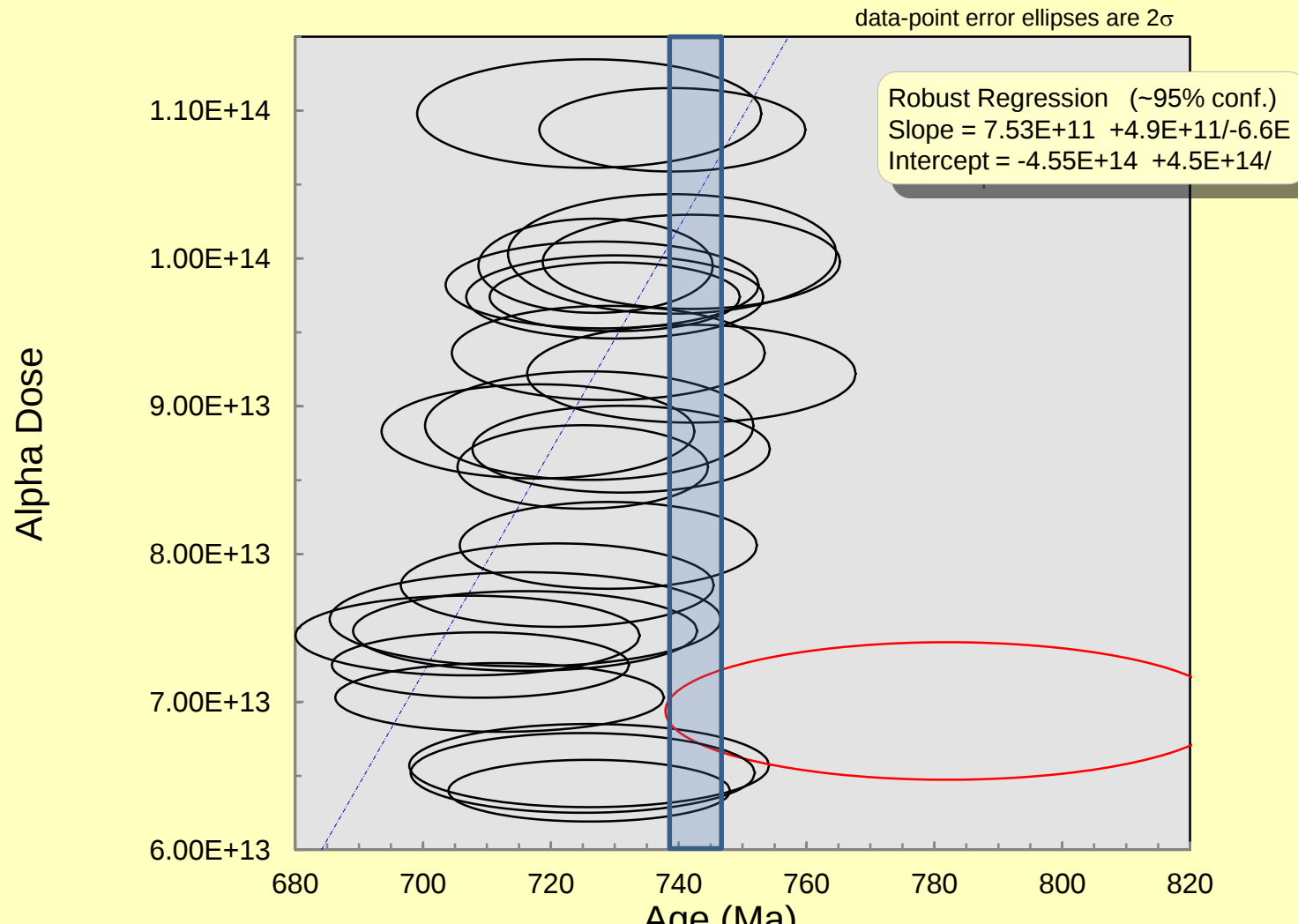
Histogram of all data



Histogram of average wave



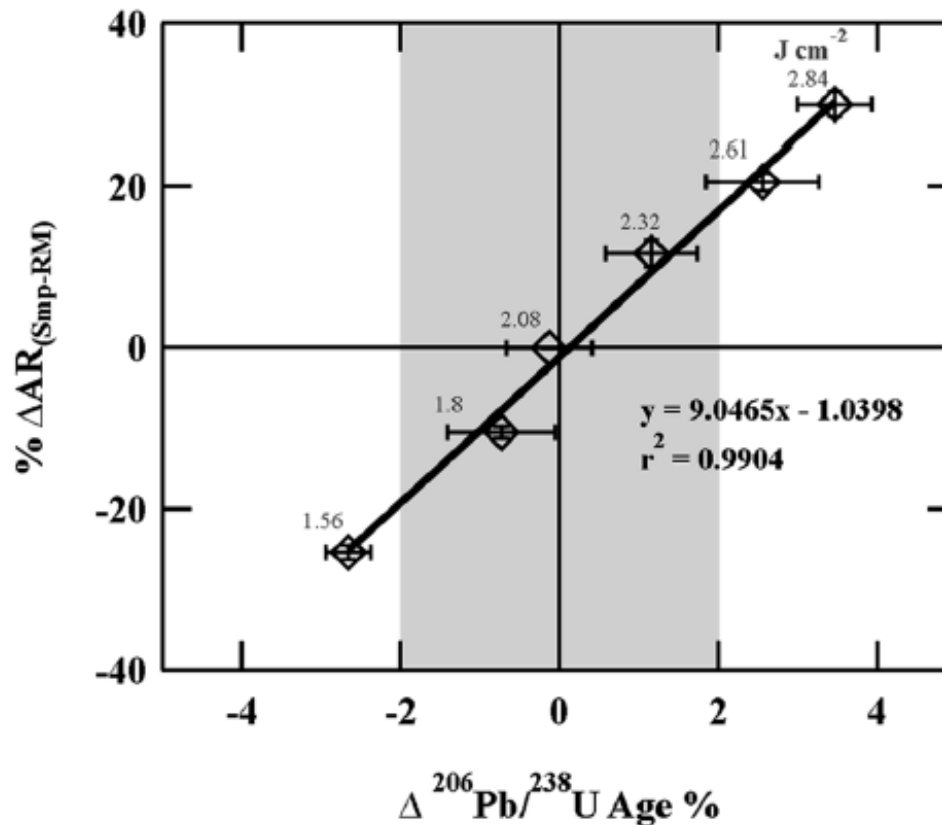
Mud Tank Non-Annealed



Age vs Ablation Rate

E. Marillo-Sialer *et al.*

The zircon 'matrix effect': evidence for an ablation rate control on the accuracy of U-Pb age determinations by LA-ICP-MS



Some Conclusions - Annealing

- Zircons display a range of ablation rates – a major factor in controlling this seems to be the alpha dose (U & Th ppm and age).
- Annealing results in lower ablation rates.
- However annealing does not make all ablation rates equal!
- There is likely an age bias proportional to the difference in alpha dose (and ablation rate) between the primary standard and unknowns.

Some Conclusions - CA

- CA is an effective pre-treatment tool to reduce the effects of Pb-loss and elevated common-Pb in zircon.
- The physical effects of CA are most visible when grains have suffered more Pb-loss.
- CA produces different ablation rates when compared to non-treated zircons, so ideally CA standards should be used.