

# Application of rapid U-Pb acquisition (3 s/analysis) to combat lithofacies bias in detrital zircon age distributions: Example from the Book Cliffs, UT

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DETRITAL-ZIRCON U-PB PALEODRAINAGE RECONSTRUCTION AND GEOCHRONOLOGY OF THE  
CAMPANIAN BLACKHAWK-CASTLEGATE SUCCESSION, WASATCH PLATEAU AND BOOK CLIFFS,  
UTAH, U.S.A.

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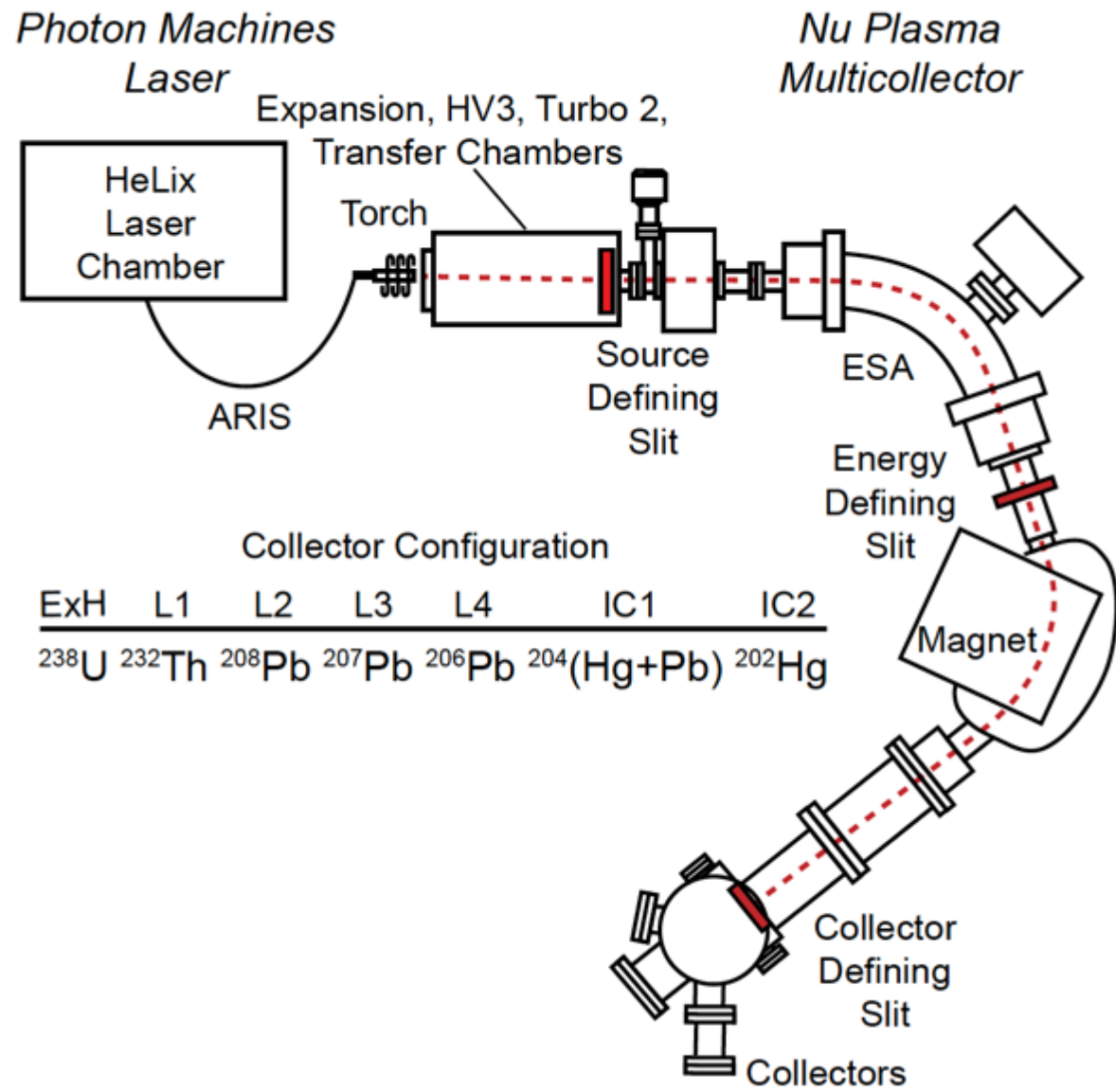
<sup>1</sup>Department of Geology, University of Kansas, Lawrence, Kansas, U.S.A.

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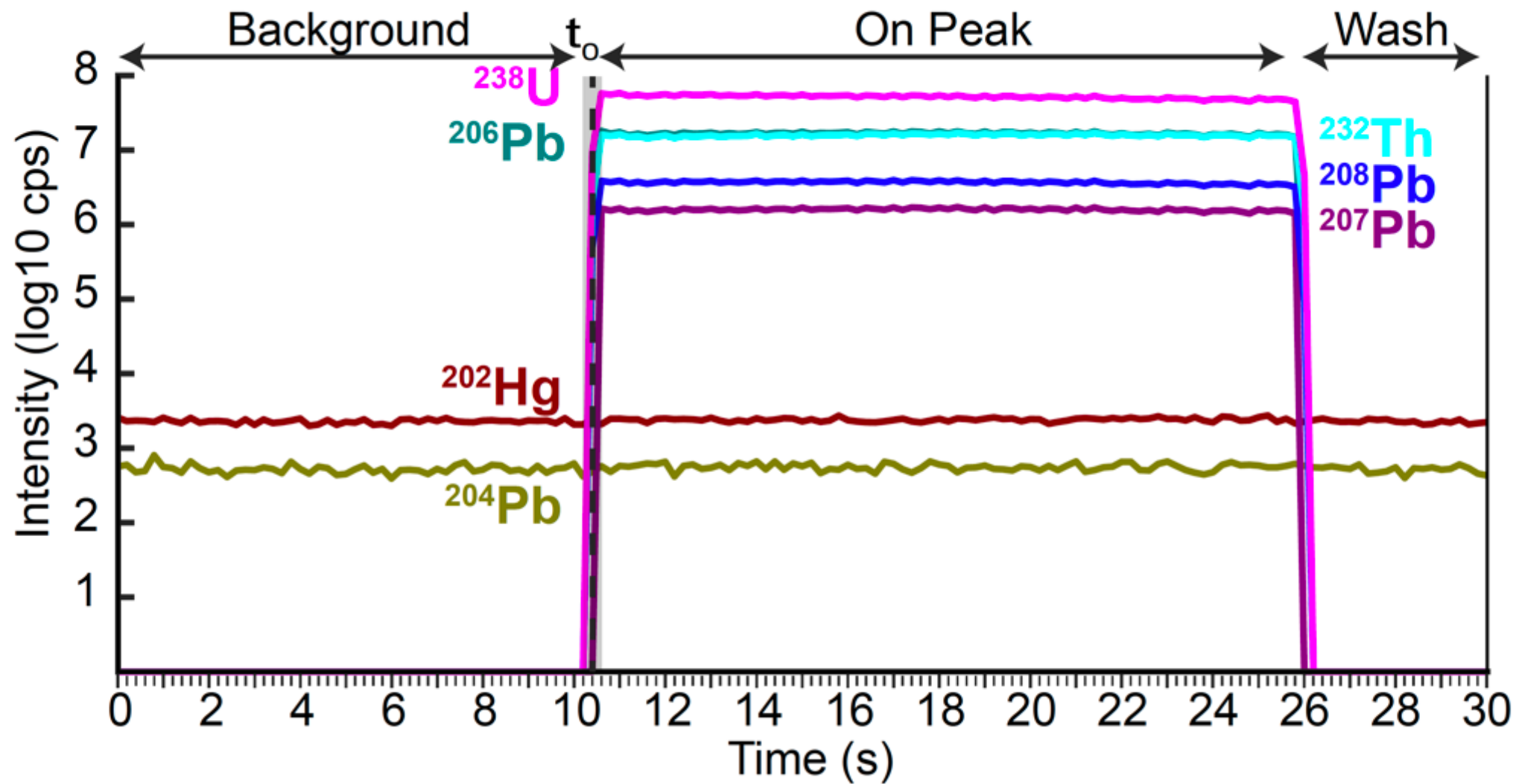
# Instrumentation: Laser Ablation Multicollector ICP-MS



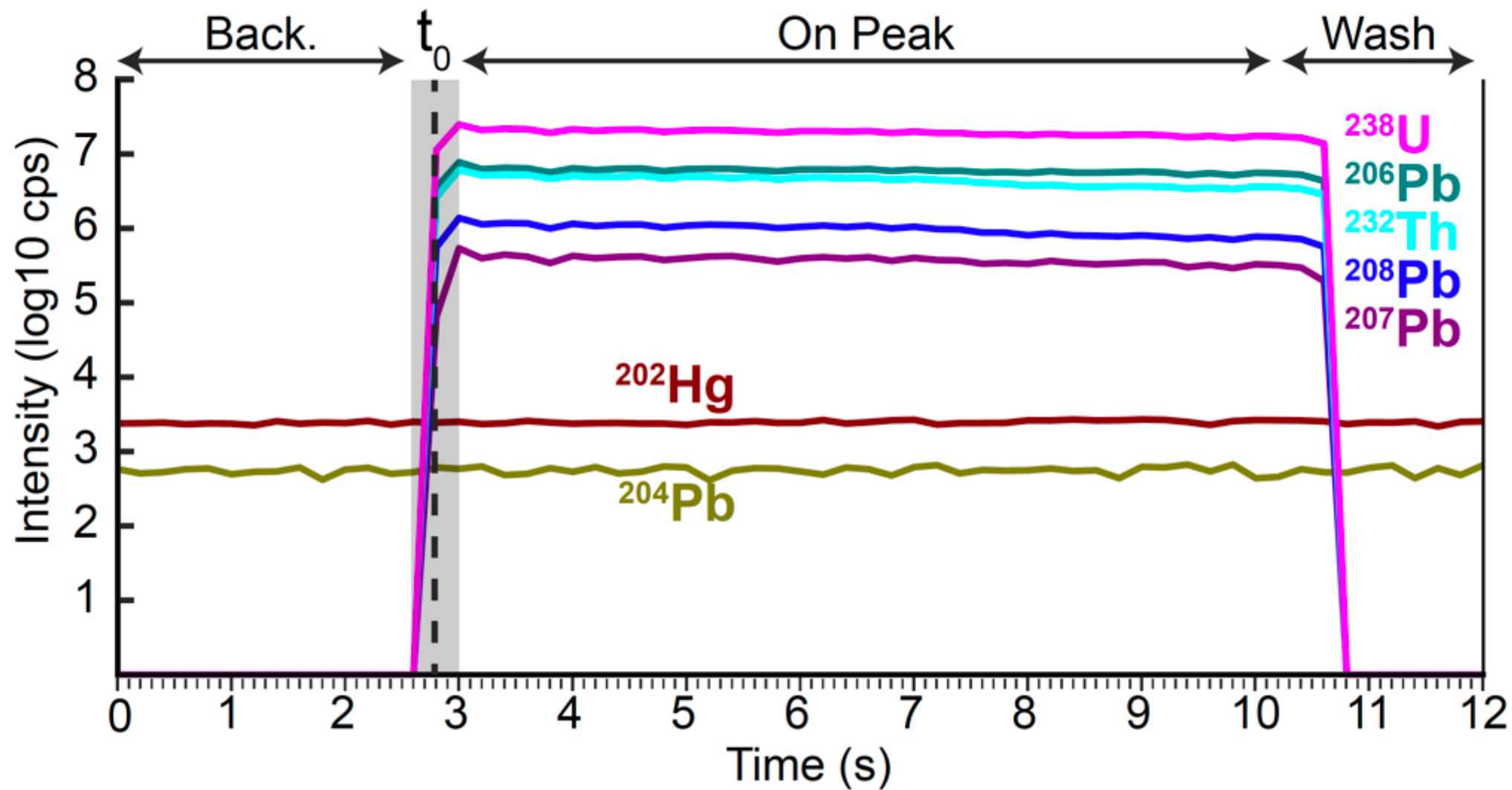
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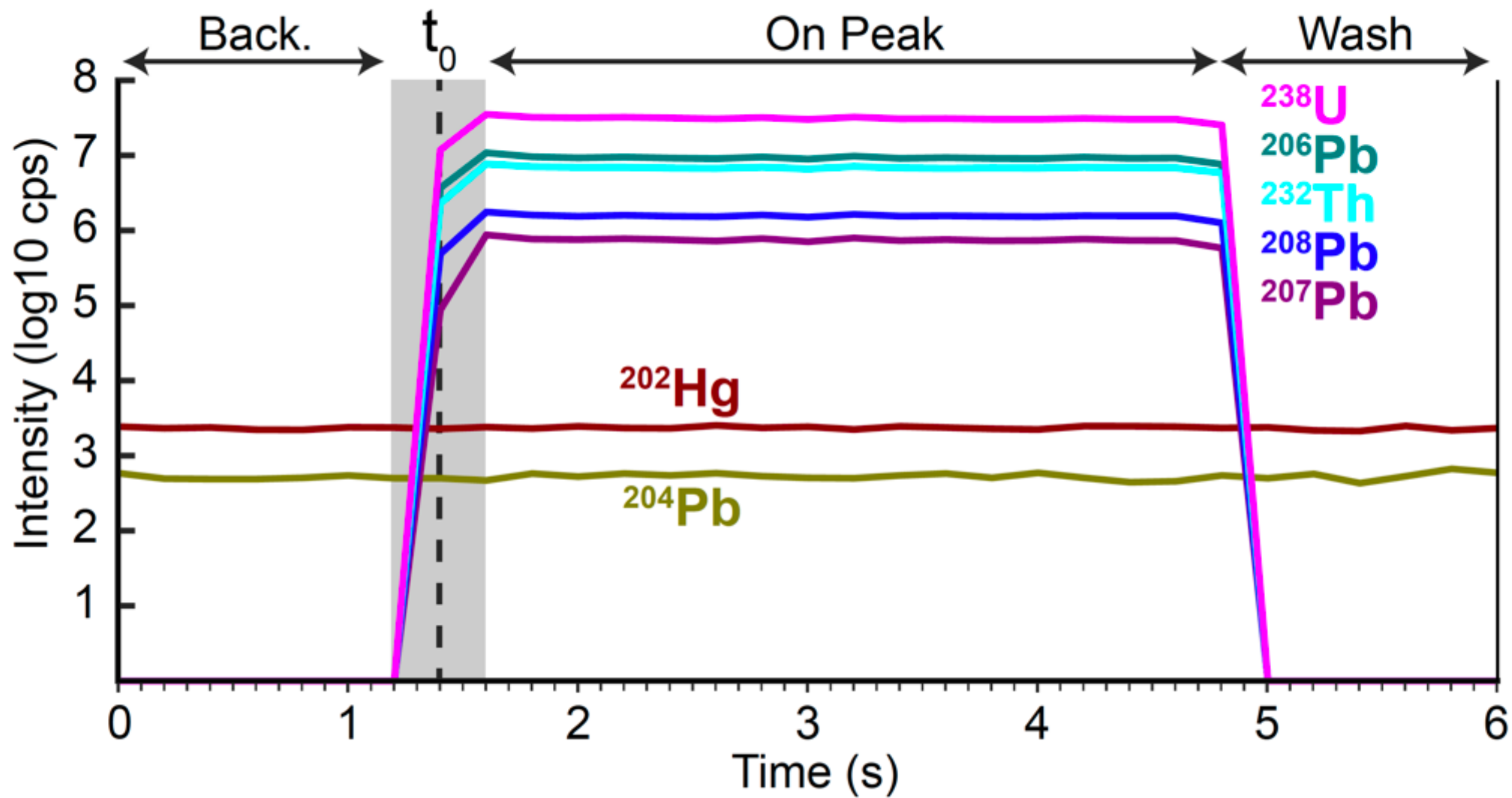
Rates of Acquisition: 120 analyses/h (30 s/analysis)



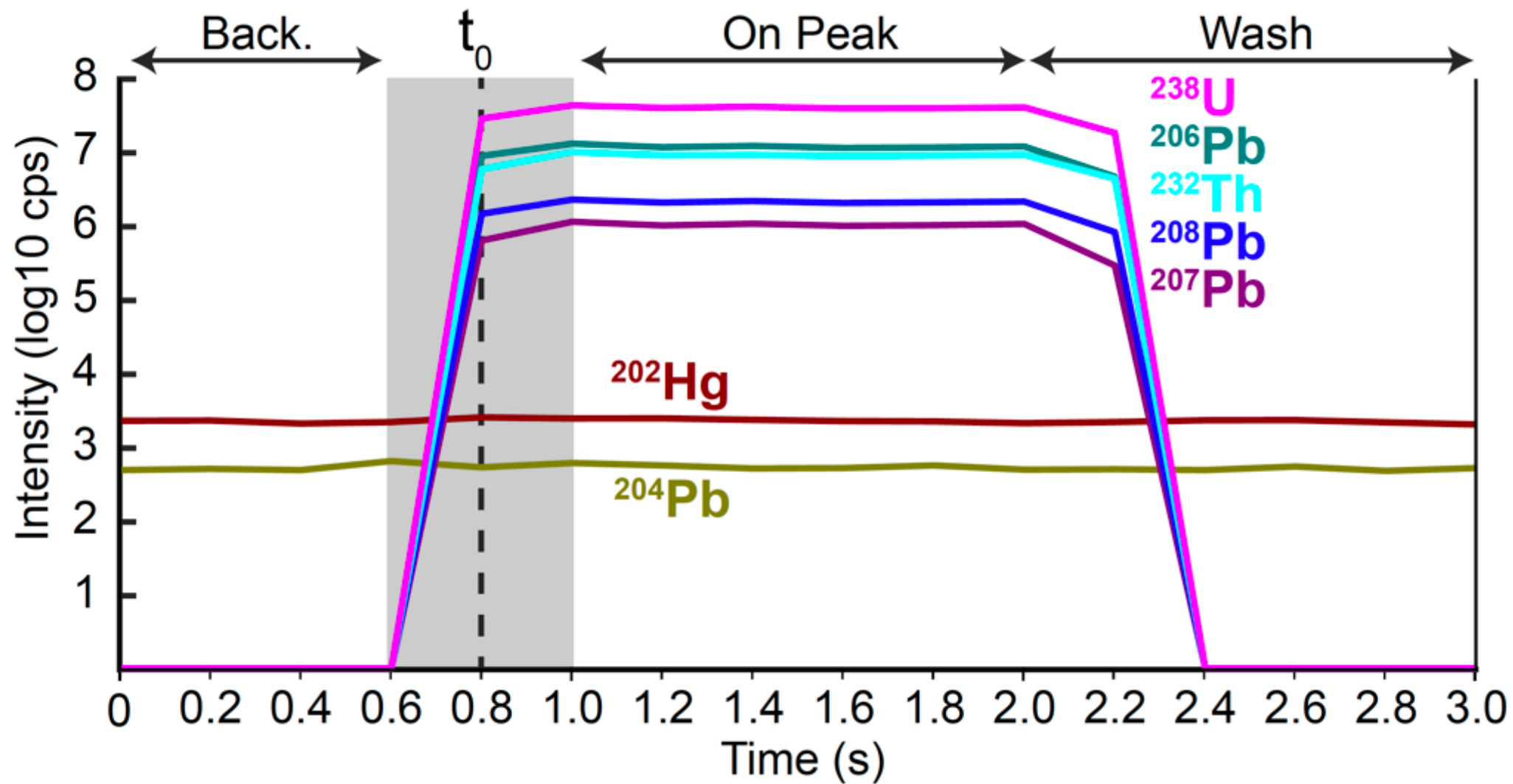
Rates of Acquisition: 300 analyses/h (12 s/analysis)



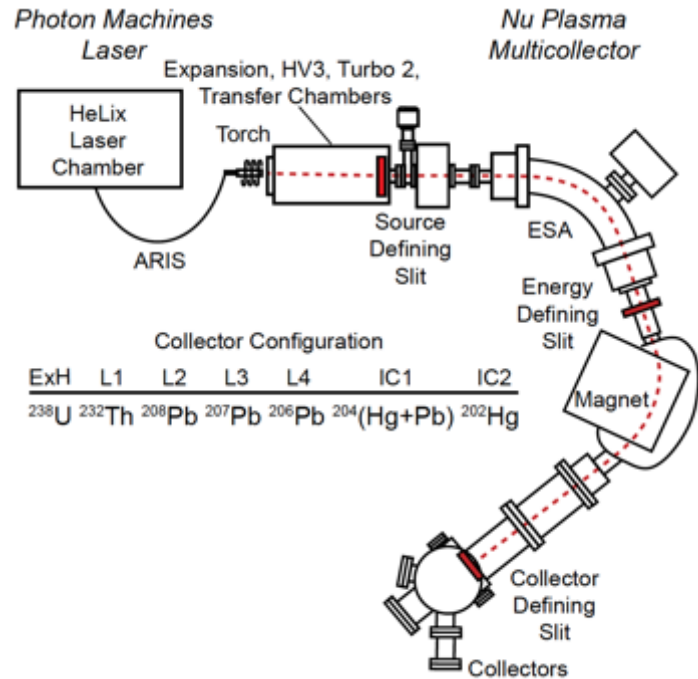
Rates of Acquisition: 600 analyses/h (6 s/analysis)



Rates of Acquisition: 1,200 analyses/h (3 s/analysis)



# Modifications to traditional LA-ICP-MS

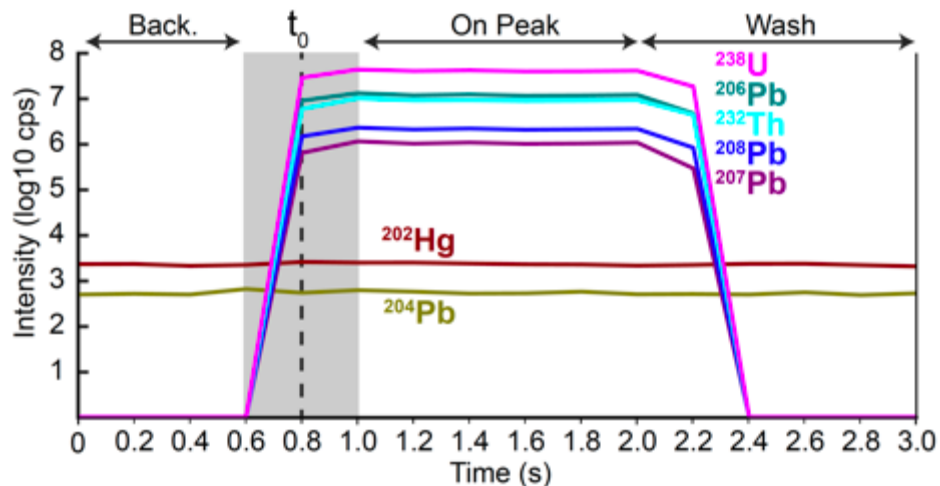


## HARDWARE

- ◆ Aerosol Rapid Introduction System (ARIS)
- ◆ No mixing chamber at the laser-plasma interface

## SOFTWARE

- ◆ Total-count method for isotopic ratios
- ◆ Modified background subtraction method
- ◆ Automated site selection, ZirconSpotFinder
- ◆ New data reduction software, AgeCalcML



# Automated Site Selection: *ZirconSpotFinder*

The screenshot displays the ZirconSpotFinder software interface. On the left is a control panel with buttons for 'Select Folder', 'Initial Processing', and 'Find Spots!'. Below these are input fields for 'Resolution' (2^13), 'Area (pixels^2)' (3500), and 'Diameter (µm)' (30). There are also checkboxes for 'On' and 'Save Cleaning Shot .scanscv', and a list of spot IDs from 1221 to 1242. At the bottom of the control panel are fields for 'Number of Unknowns' (1200), 'Number and Range of Primaries' (250, 1201 - 1450), 'Number and Range of Secondaries' (48, 1451 - 1498), and 'Sample Name' (Spot).

The top right shows a 'Min Intensity' of 20 and 'Max Intensity' of 120. Below this is a histogram with a 'Log Scale' checkbox checked. The histogram shows a distribution of spot intensities with a red vertical line at 20. To the right of the histogram are radio buttons for 'Unknowns' (checked), 'Primaries', 'Secondaries', 'Grayscale Image' (checked), and 'Binary Image'.

The main area contains two images: a grayscale spot map on the left with a red circle highlighting a spot, and a color-coded spot map on the right showing many spots in green and red. Below the grayscale map is a table of spot data:

Spot	Type	Description	Selected	Lock	Edit	Vertex	Count	Vertex	List	Preablation	Settings	Ablation	Settings
Spot 1	FC-1	1,0,1,74003.13,49664.38,15600.00											
Spot 2	FC-1	1,0,1,73975.63,49695.00,15600.00											
Spot 3	FC-1	1,0,1,74029.38,49687.50,15600.00											
Spot 4	FC-1	1,0,1,74002.50,49716.88,15600.00											
Spot 5	FC-1	1,0,1,73973.75,49746.25,15600.00											
Spot 6	FC-1	1,0,1,73947.50,49721.25,15600.00											
Spot 7	FC-1	1,0,1,73931.88,49765.63,15600.00											
Spot 8	FC-1	1,0,1,73961.25,49781.25,15600.00											
Spot 9	FC-1	1,0,1,73978.13,49817.50,15600.00											
Spot 10	FC-1	1,0,1,73939.38,49812.50,15600.00											
Spot 11	FC-1	1,0,1,73995.63,49848.75,15600.00											
Spot 12	FC-1	1,0,1,74511.25,49868.13,15600.00											
Spot 13	FC-1	1,0,1,74486.88,49839.38,15600.00											
Spot 14	FC-1	1,0,1,74448.13,49813.75,15600.00											
Spot 15	FC-1	1,0,1,74437.50,49775.00,15600.00											
Spot 16	FC-1	1,0,1,74413.13,49744.38,15600.00											
Spot 17	FC-1	1,0,1,74581.25,49680.00,15600.00											

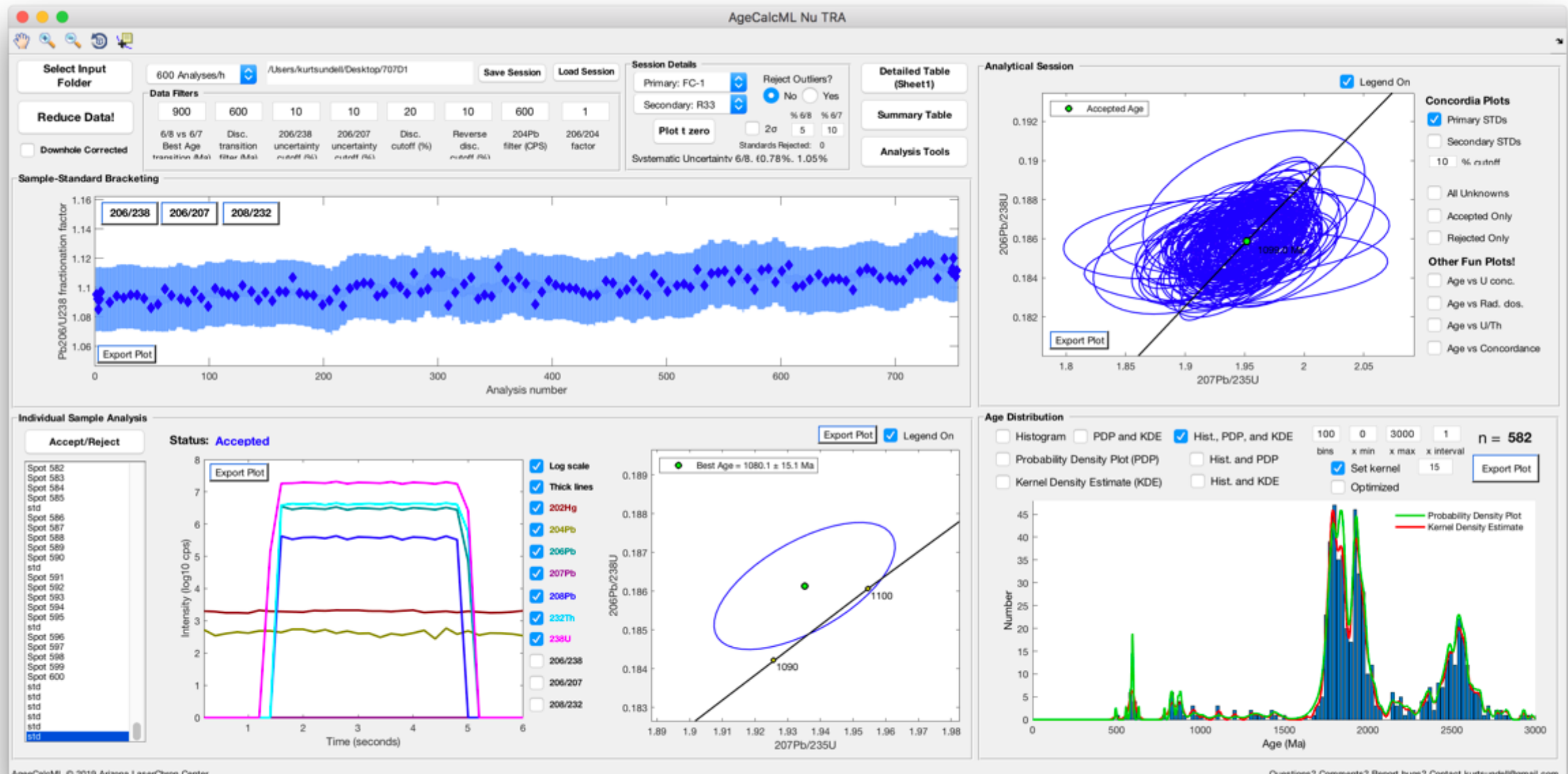
Below the grayscale map is a table of spot data:

Spot	Type	Description	Selected	Lock	Edit	Vertex	Count	Vertex	List	Preablation	Settings	Ablation	Settings
Spot 1	FC-1	1,0,1,76093.13,50237.50,15600.00											
Spot 2	FC-1	1,0,1,75865.63,49915.00,15600.00											
Spot 3	FC-1	1,0,1,77130.00,49990.00,15600.00											
Spot 4	FC-1	1,0,1,76949.38,50186.25,15600.00											
Spot 5	FC-1	1,0,1,74280.00,50294.38,15600.00											
Spot 6	R33	1,0,1,74918.75,49218.75,15600.00											
Spot 7	R33	1,0,1,74792.50,49280.63,15600.00											
Spot 8	R33	1,0,1,74258.00,51124.00,15600.00											
Spot 9	R33	1,0,1,74255.00,51968.00,15600.00											
Spot 10	R33	1,0,1,74249.00,52173.00,15600.00											
Spot 11	R33	1,0,1,74271.00,52904.00,15600.00											
Spot 12	R33	1,0,1,74241.00,53348.00,15600.00											
Spot 13	FC-1	1,0,1,74228.75,50148.75,15600.00											
Spot 14	FC-1	1,0,1,74263.00,53608.00,15600.00											
Spot 15	FC-1	1,0,1,74253.00,53979.00,15600.00											
Spot 16	FC-1	1,0,1,74244.00,54044.00,15600.00											
Spot 17	FC-1	1,0,1,74253.00,52525.00,15600.00											

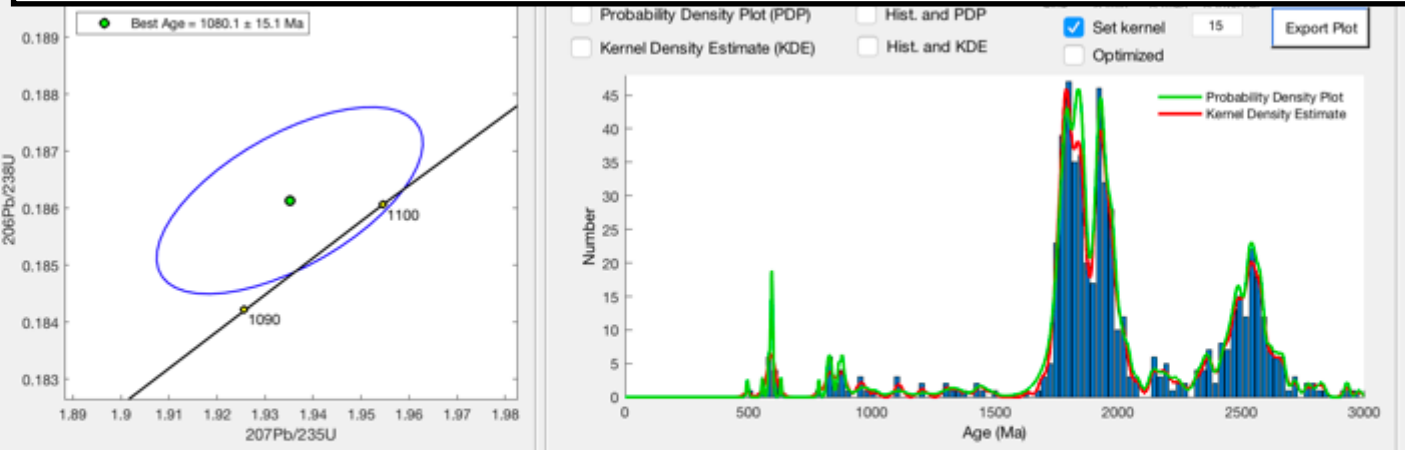
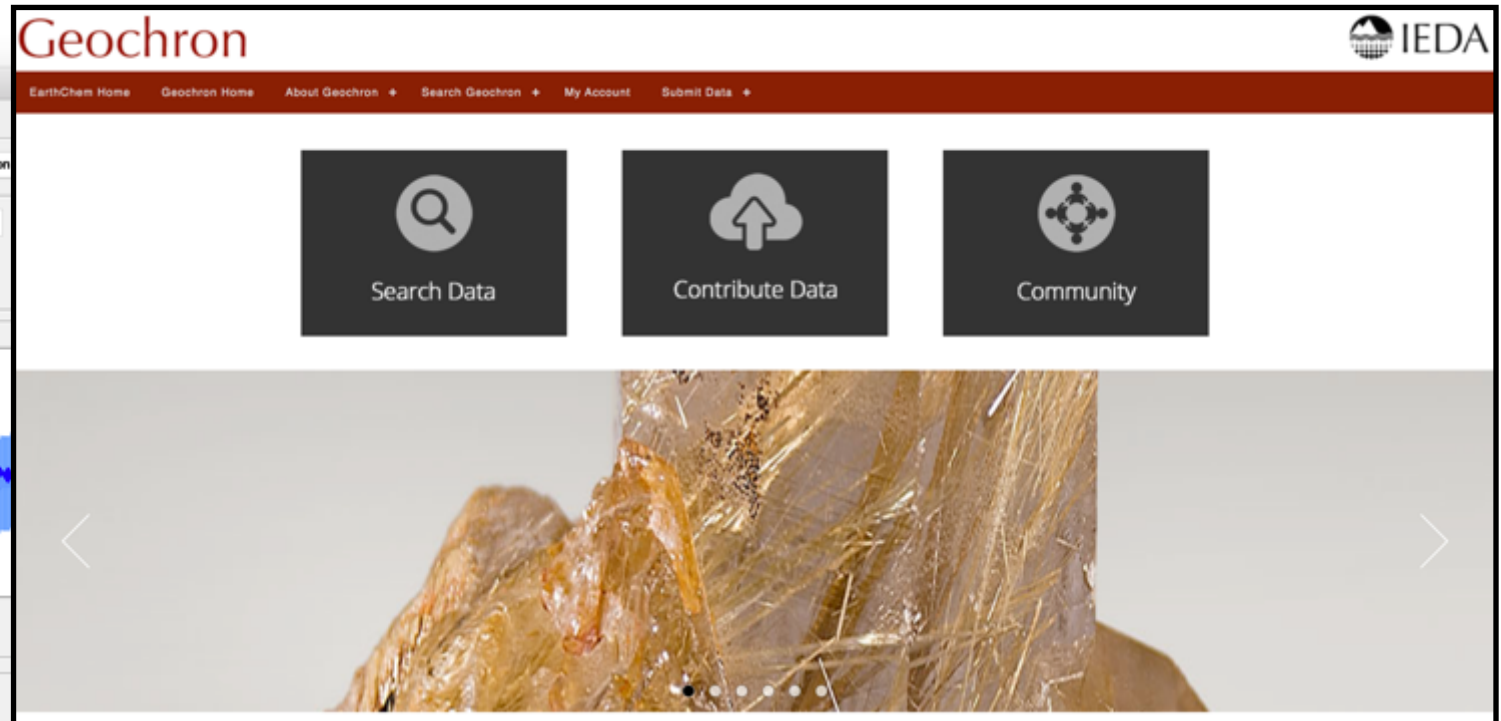
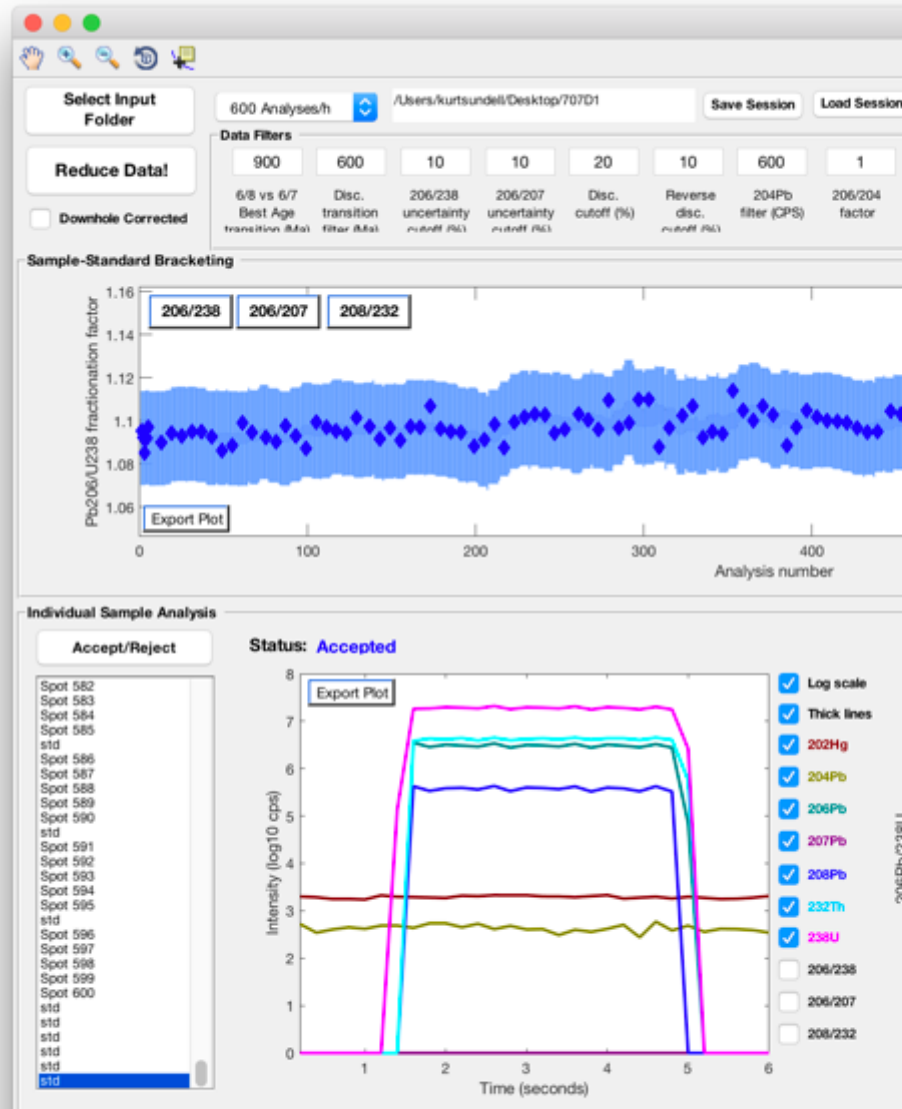
At the bottom of the interface, there is a footer with the text 'ZirconSpotFinder ©2019 Arizona Laser Chron Center' and a link to 'Questions? Comments? Report bugs? Contact kurtsundell@gmail.com'.



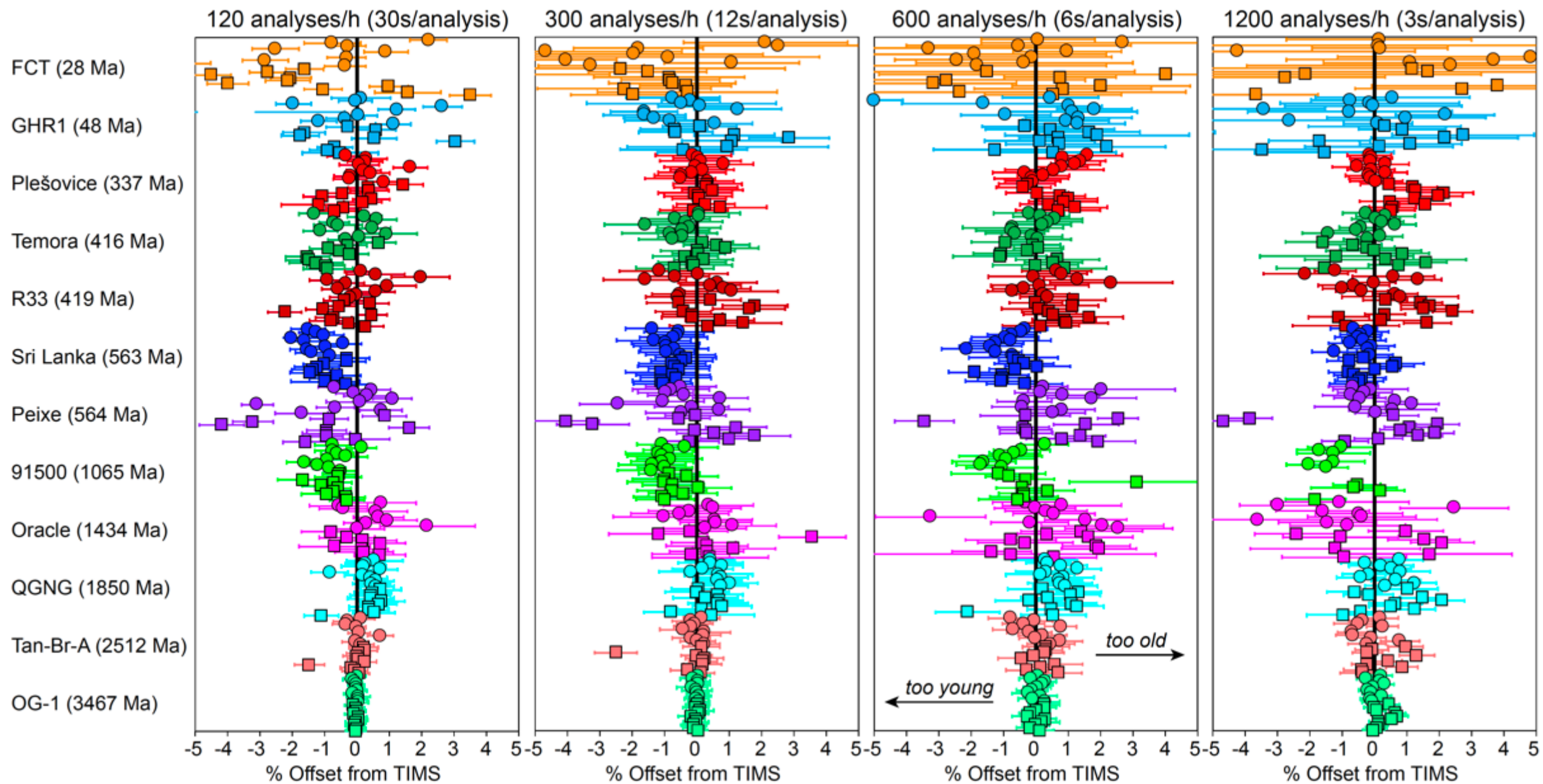
# New Data Reduction Software: *AgeCalcML*



# New Data Reduction Software: *AgeCalcML*



# Round Robin Standard Testing



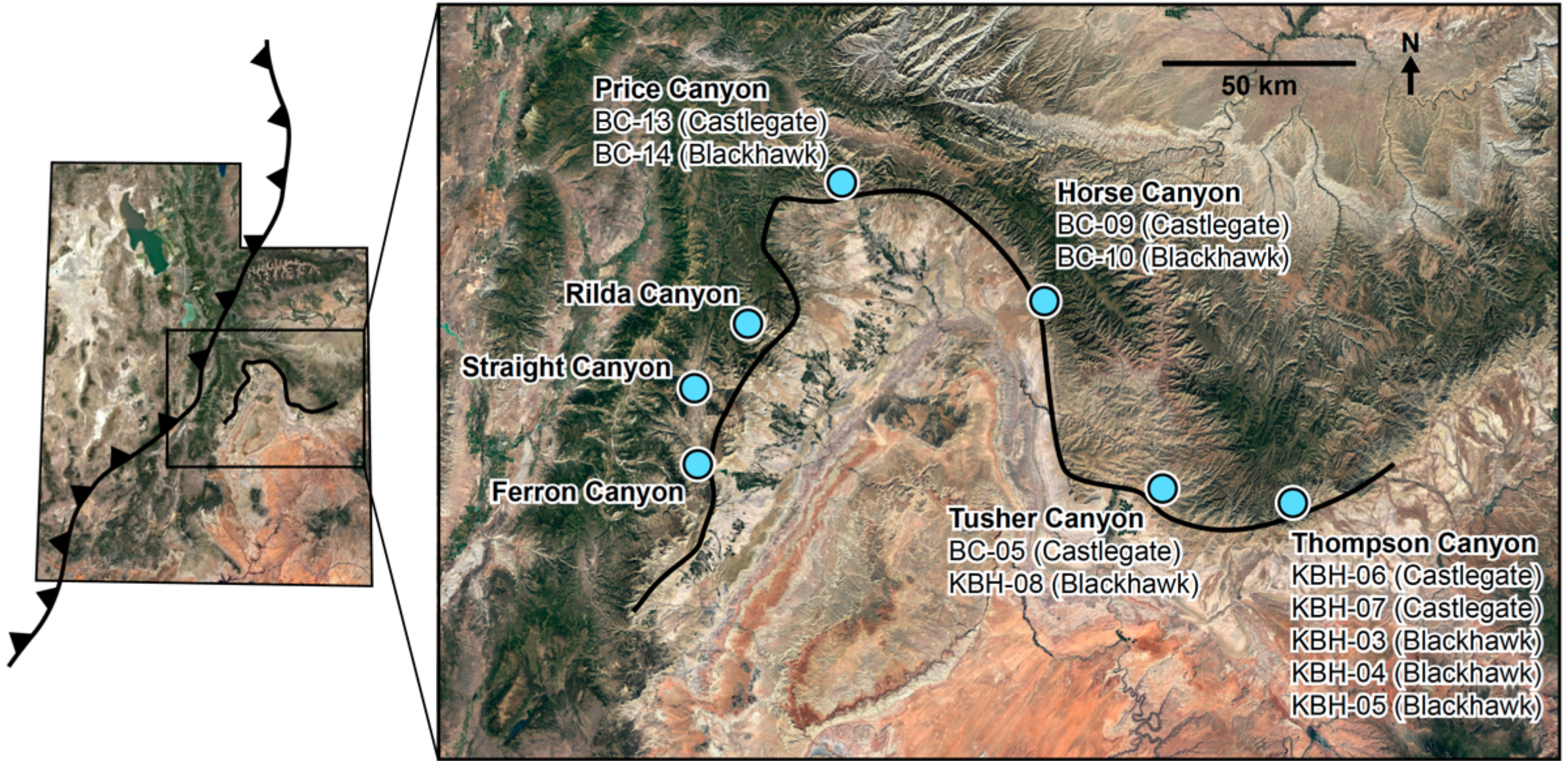
# Sevier Orogeny



Sevier front after Camilleri and Chamberlain (1997)

Figure courtesy of Tyson Smith, after Weil and Yonkee (2012)

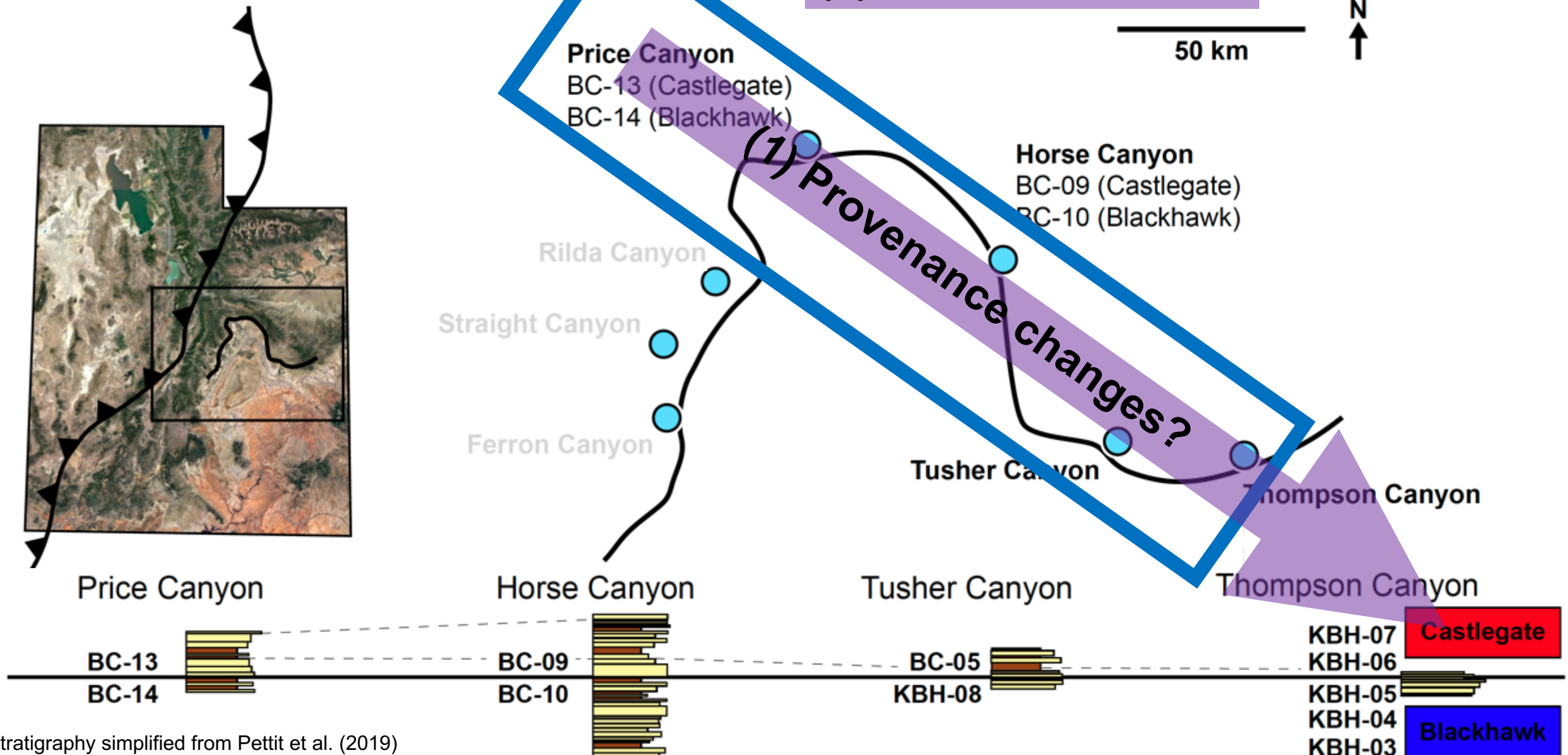
# Book Cliffs, Utah



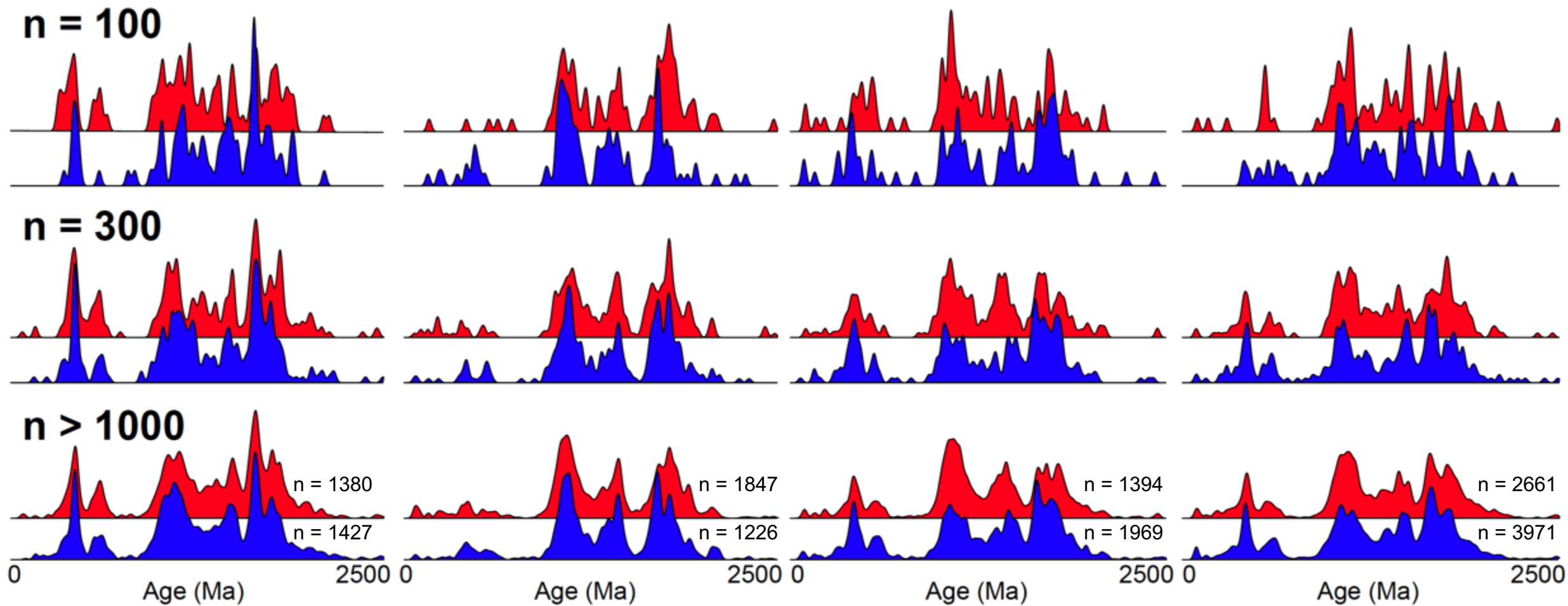
# Three Questions...

(2) Maximum depositional age?

(3) Lithofacies bias?



# Results



Price Canyon

Horse Canyon

Tusher Canyon

Thompson Canyon

BC-13  
BC-14

BC-09  
BC-10

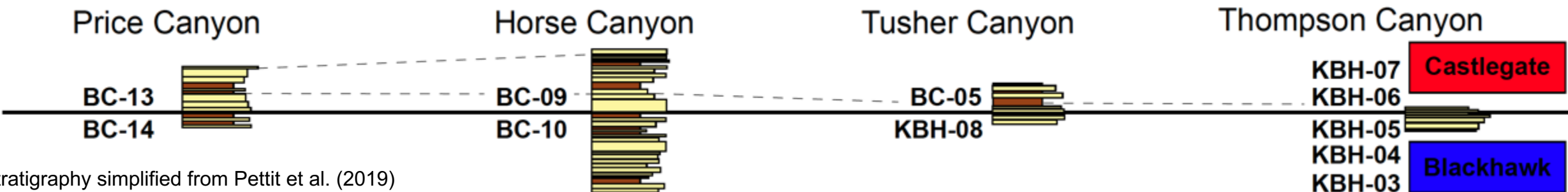
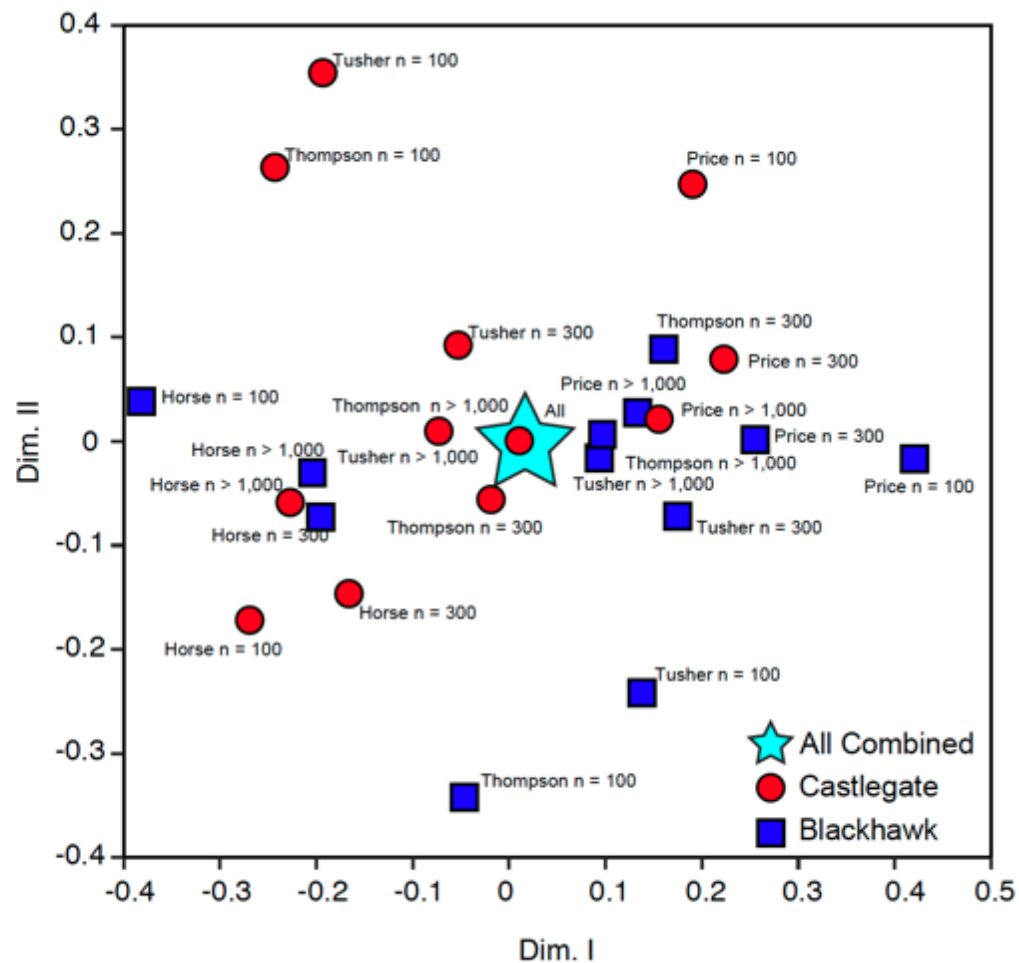
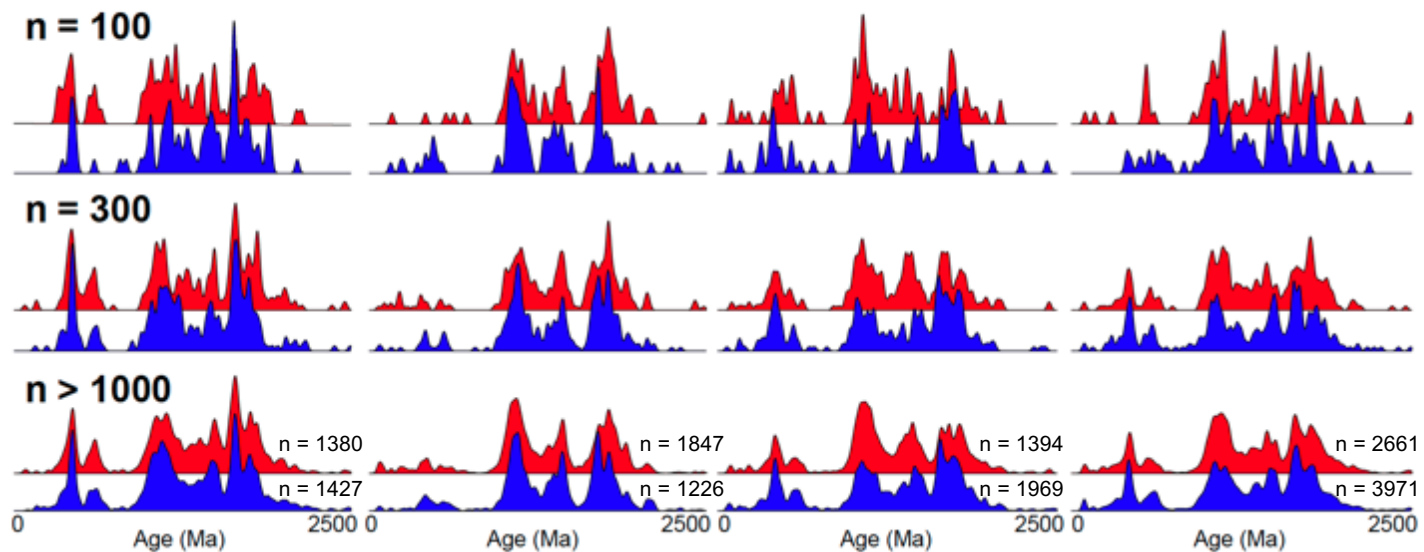
BC-05  
KBH-08

KBH-07  
KBH-06  
KBH-05  
KBH-04  
KBH-03

Castlegate

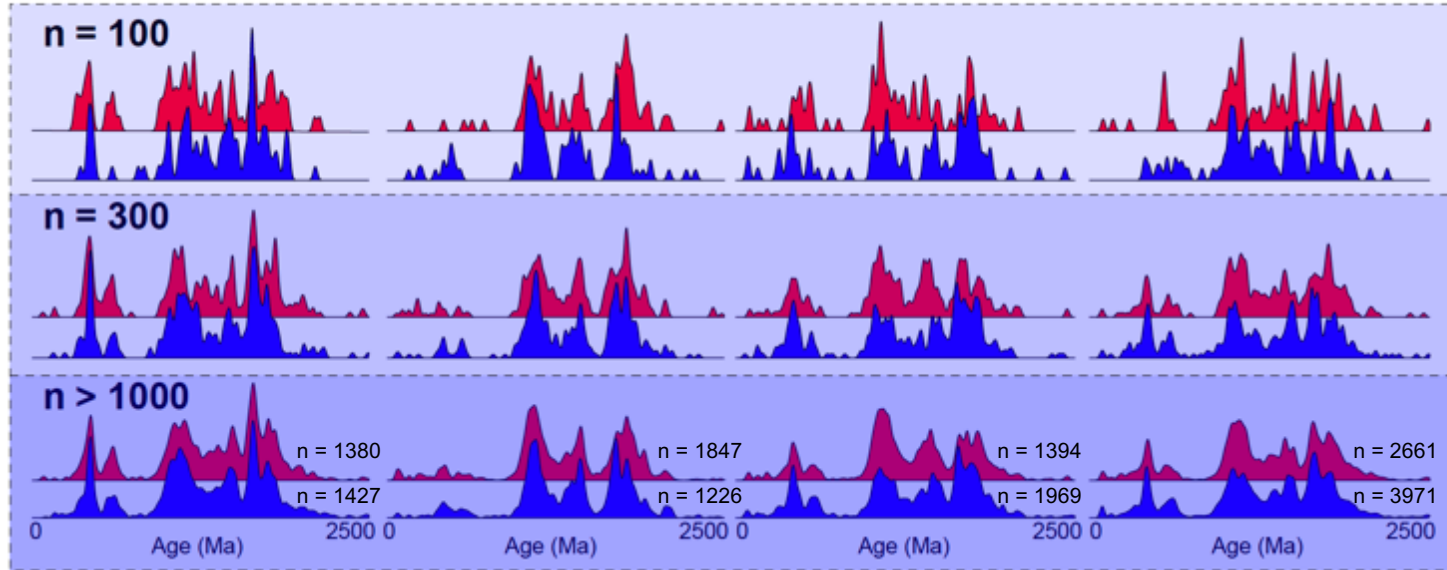
Blackhawk

# (1) Provenance Changes?

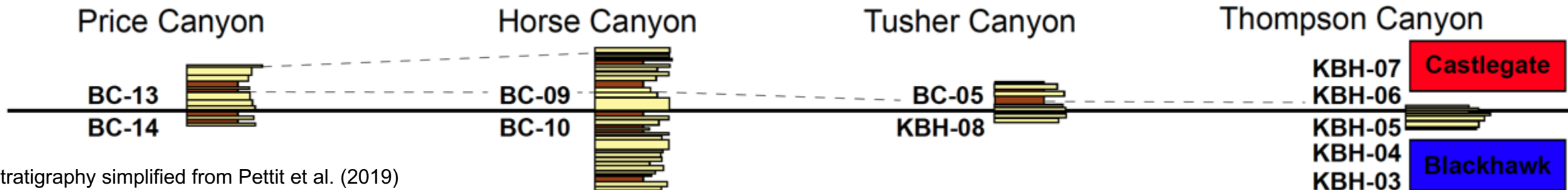
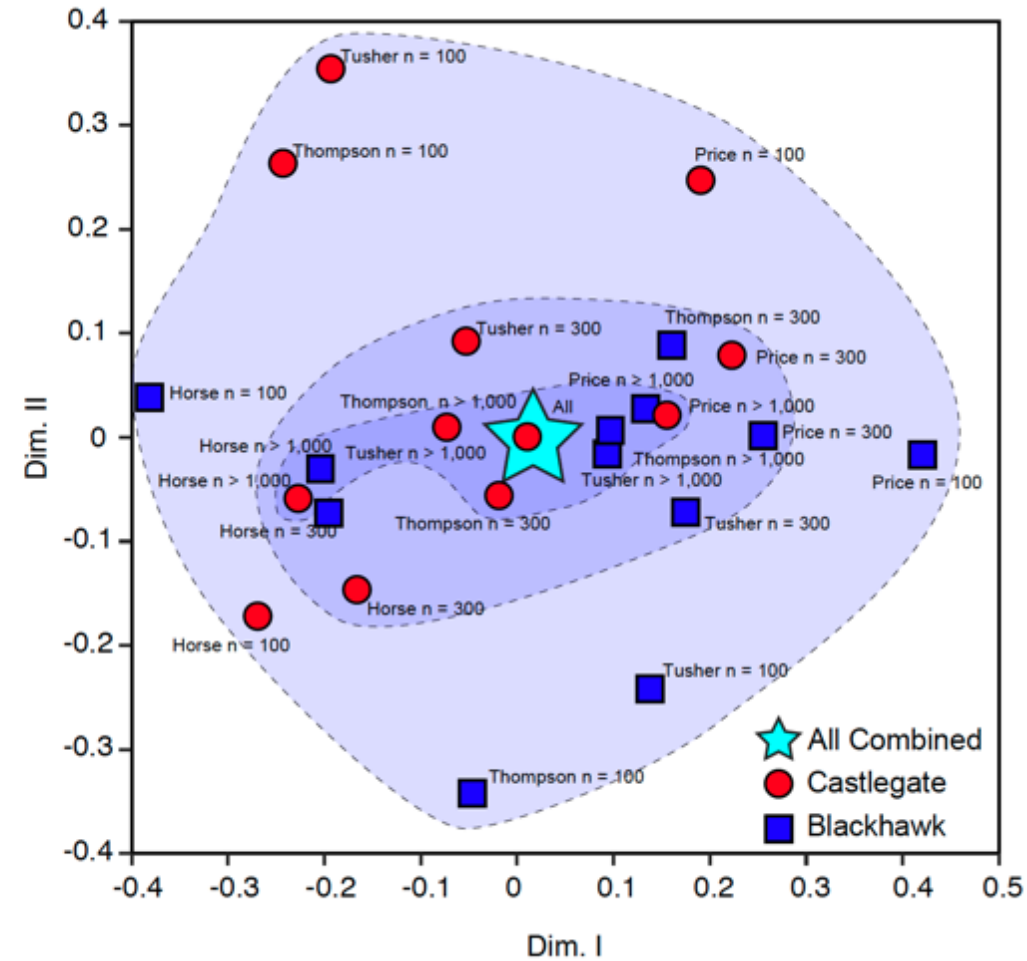




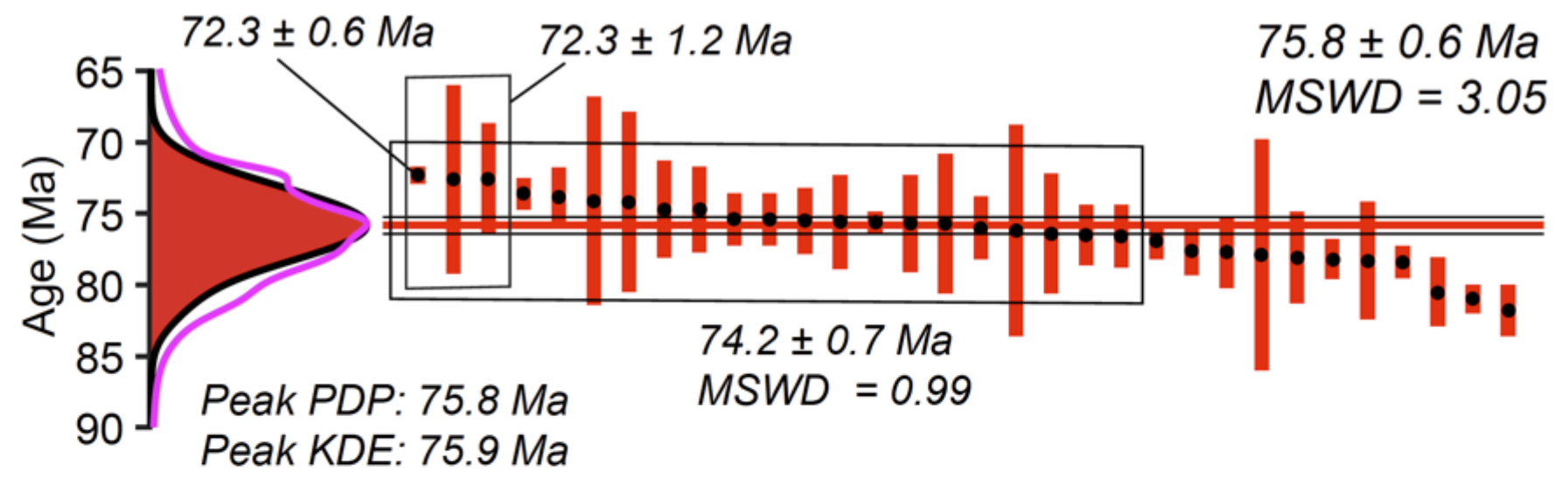
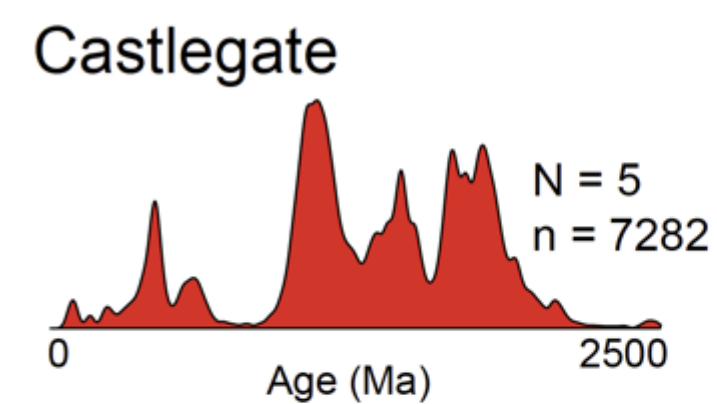
# (1) Provenance Changes?



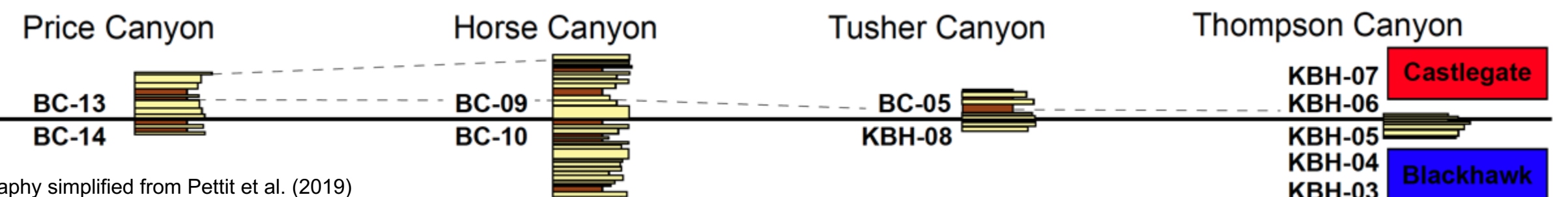
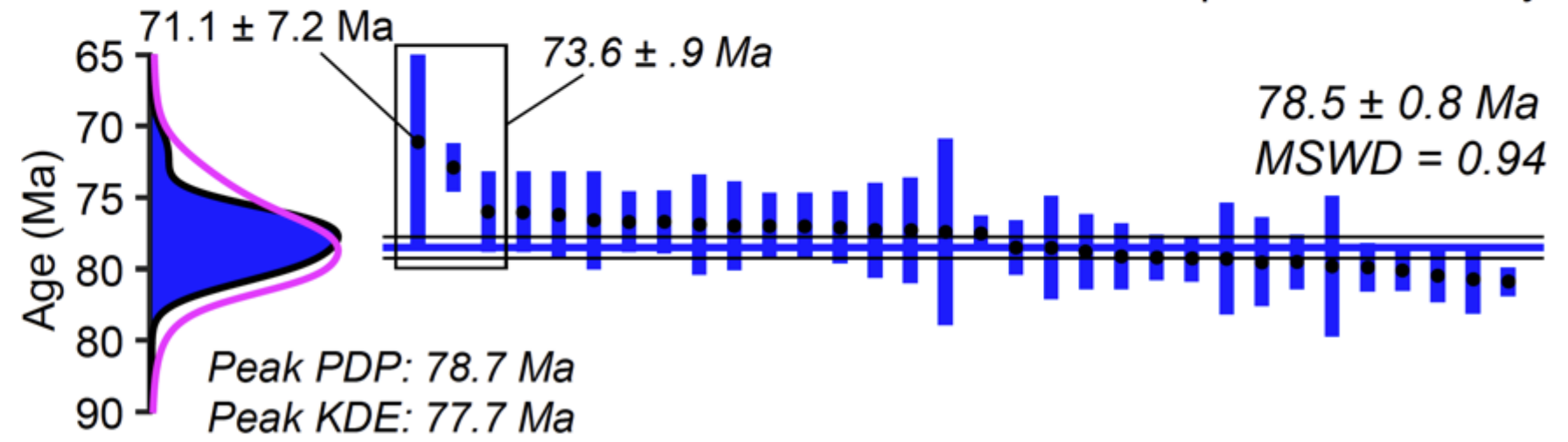
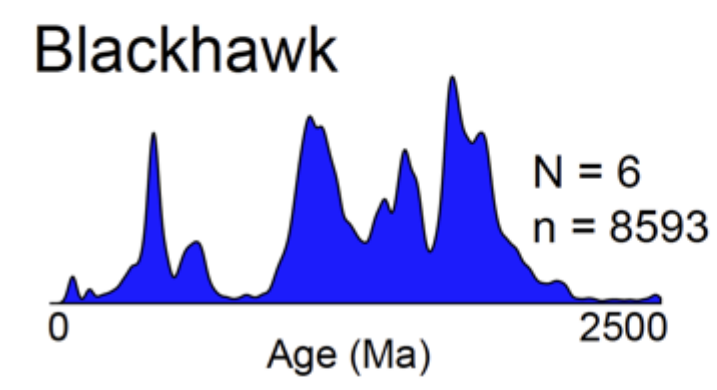
***No up-section or down-dip provenance changes along the Blackhawk-Castlegate sequence boundary***



## (2) MDAs?

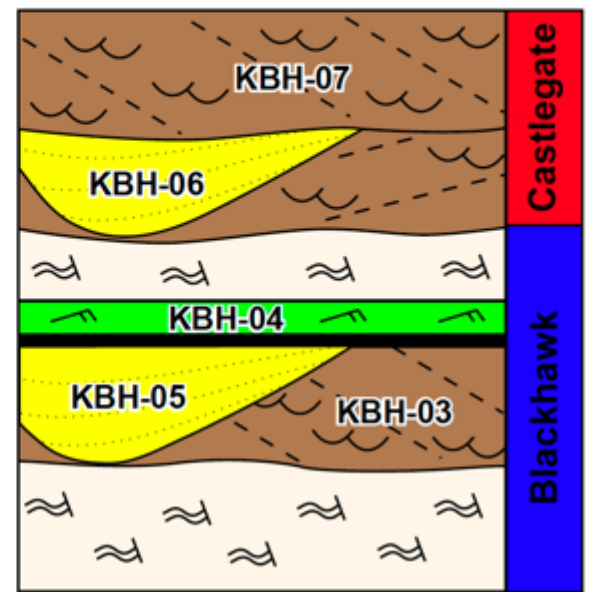
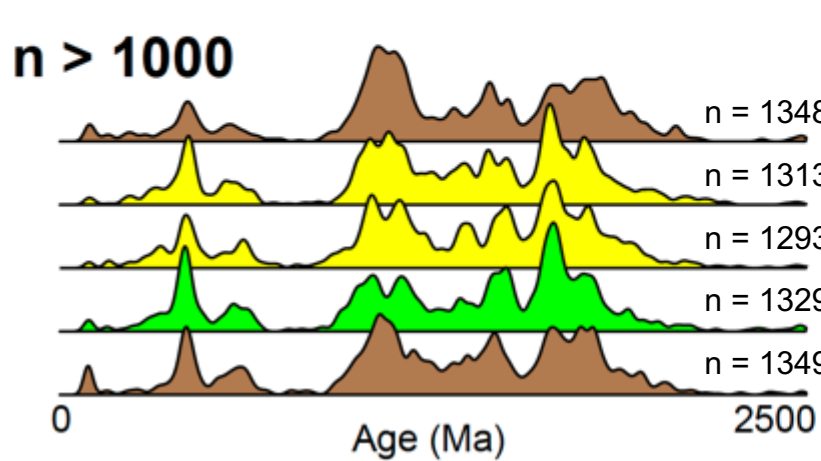
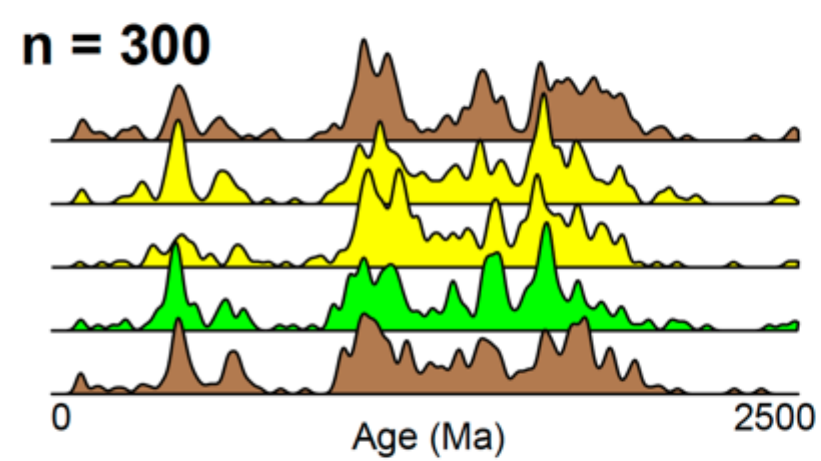
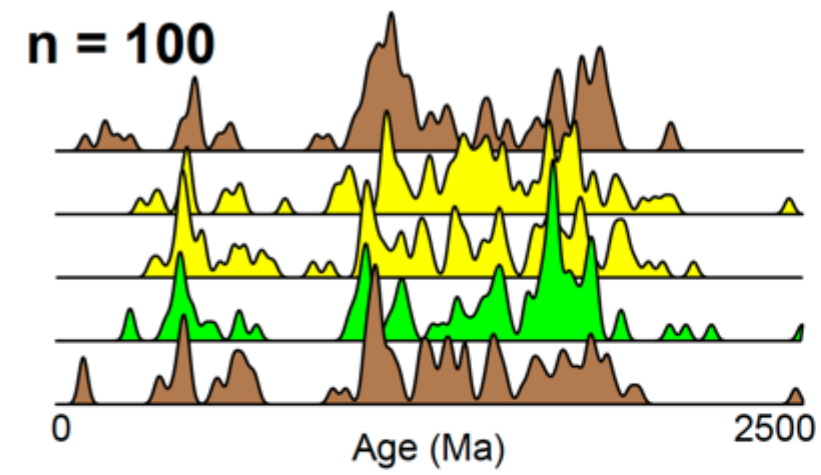
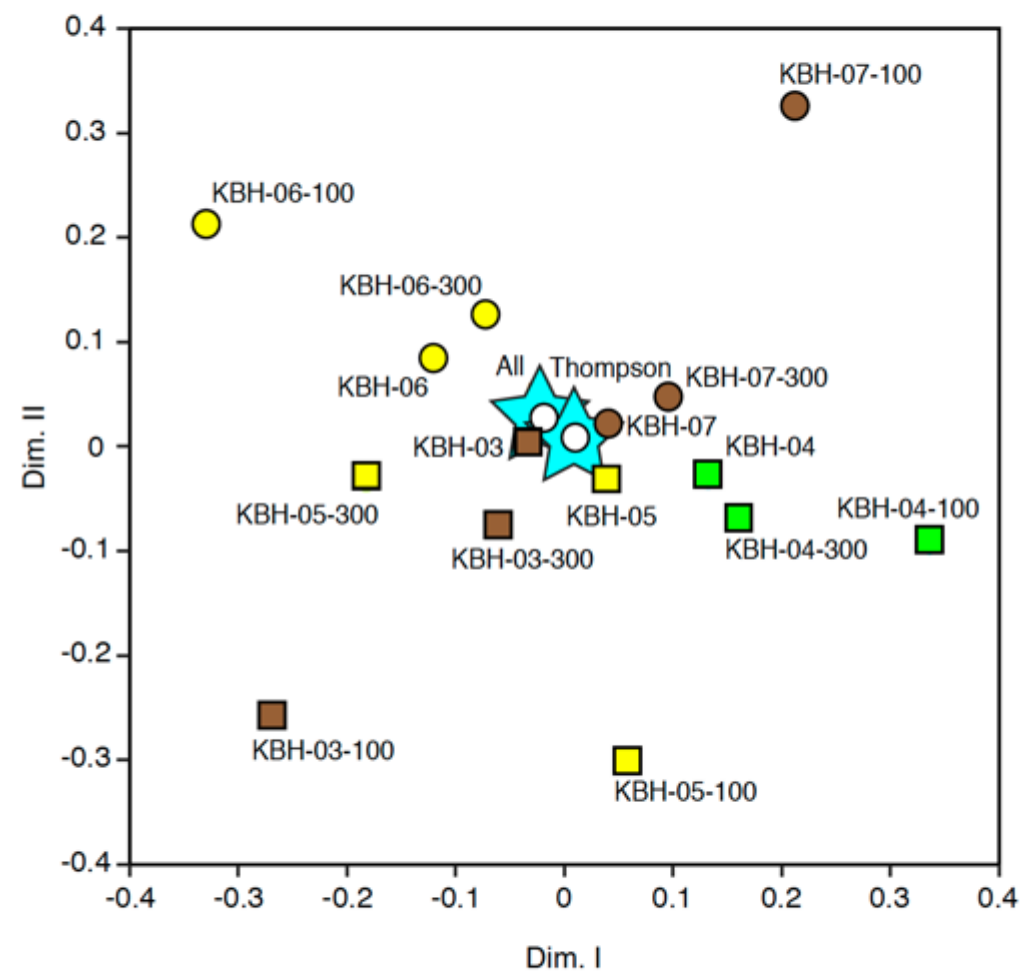


sequence boundary



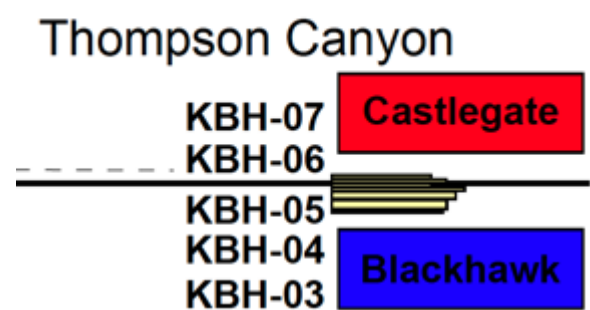
Stratigraphy simplified from Pettit et al. (2019)

# (3) Lithofacies Bias?

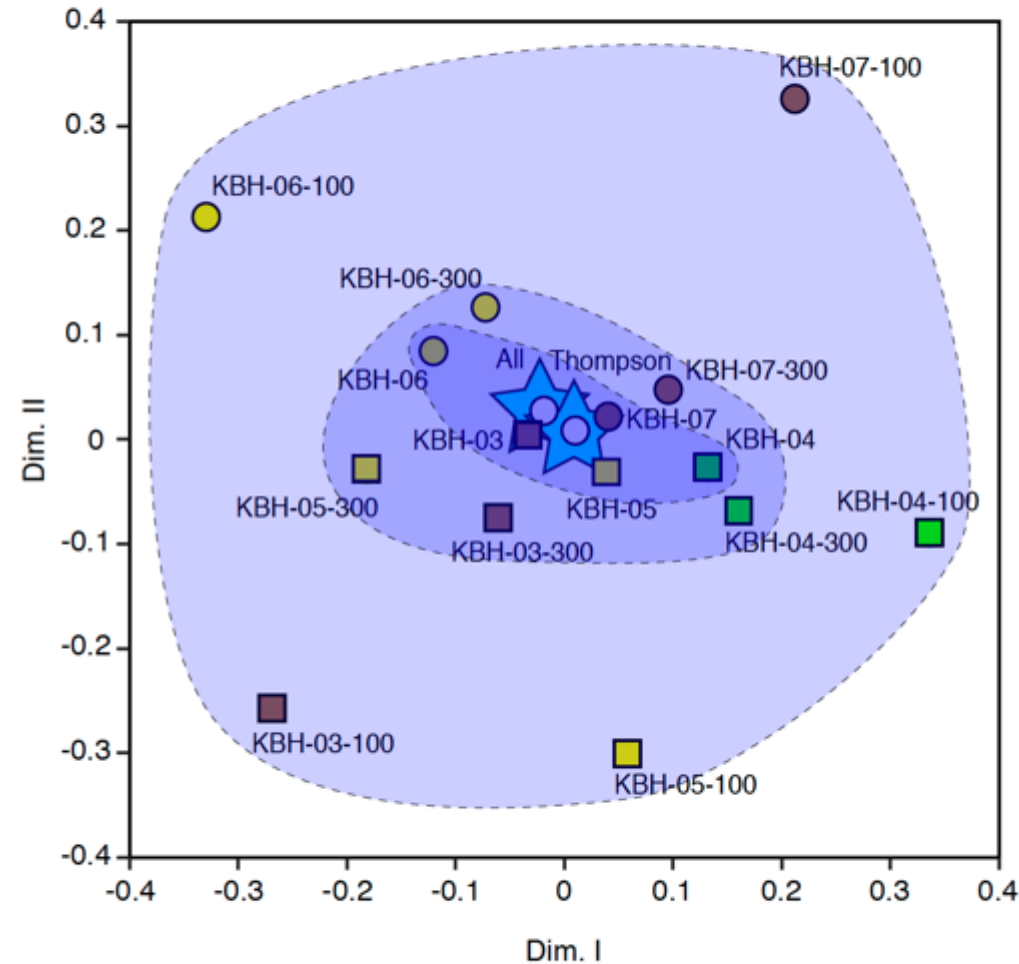


- Crevasse Splay
- Channel Belt
- Inclined Heterolithic Strata
- Hummocky Sandstone

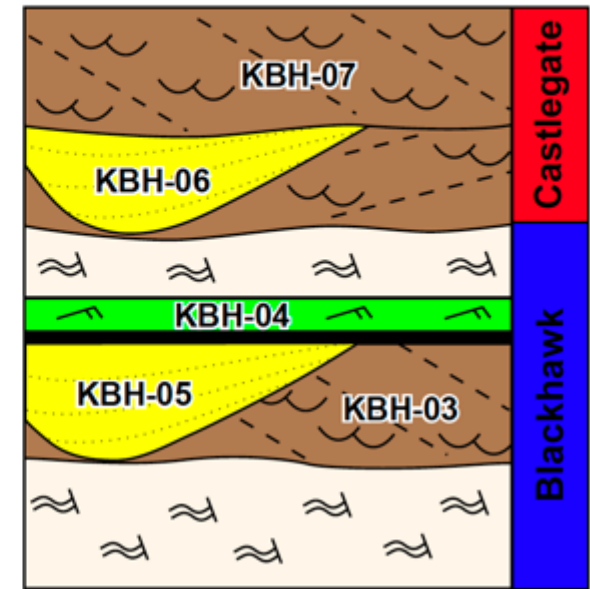
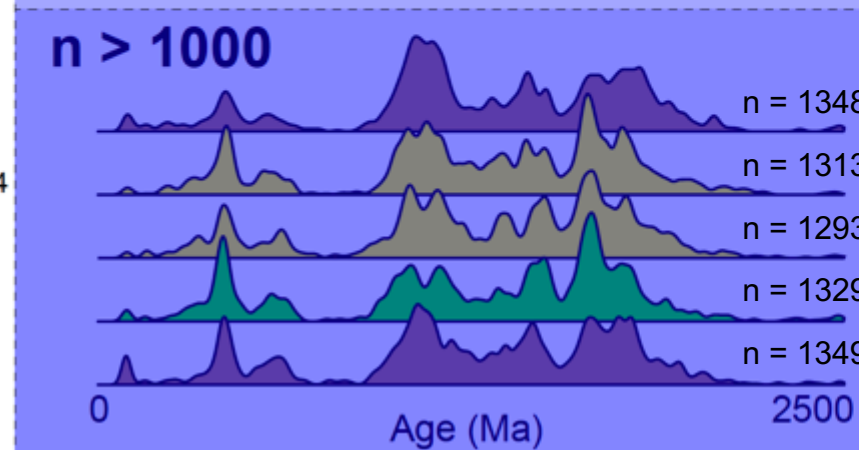
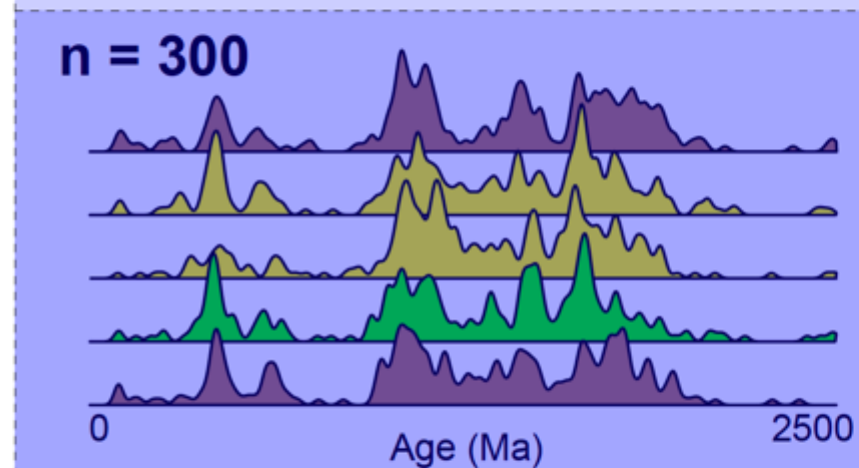
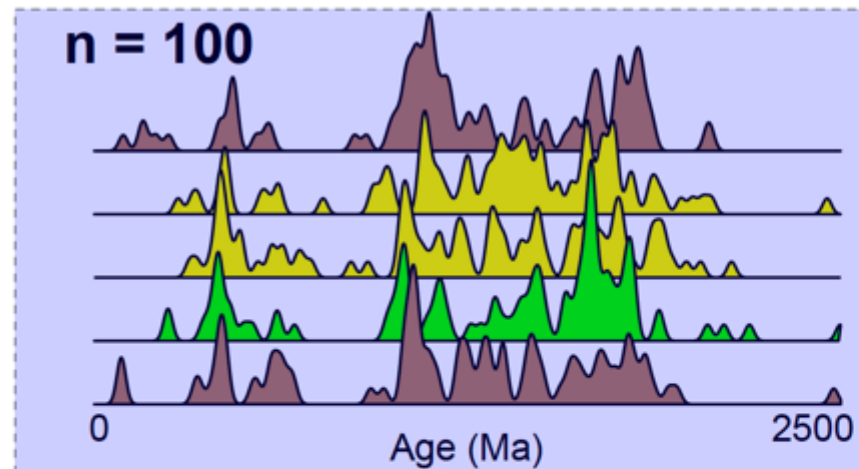
Modified from Pettit et al. (2019)



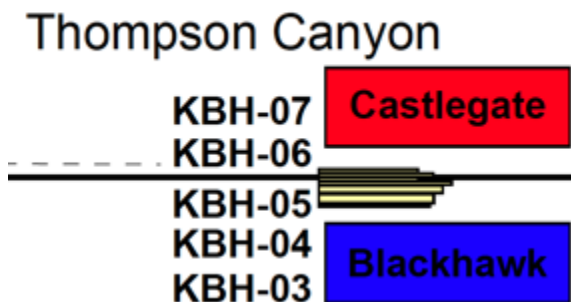
### (3) Lithofacies Bias?



***Increased sample size reduces lithofacies bias***

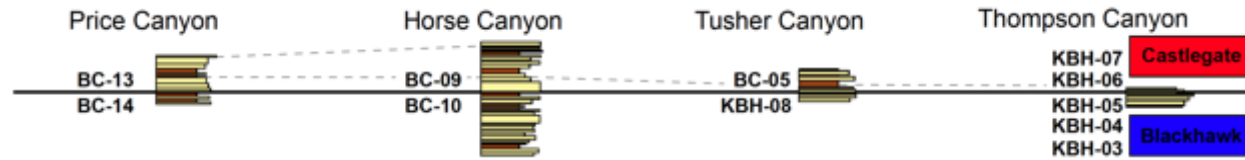
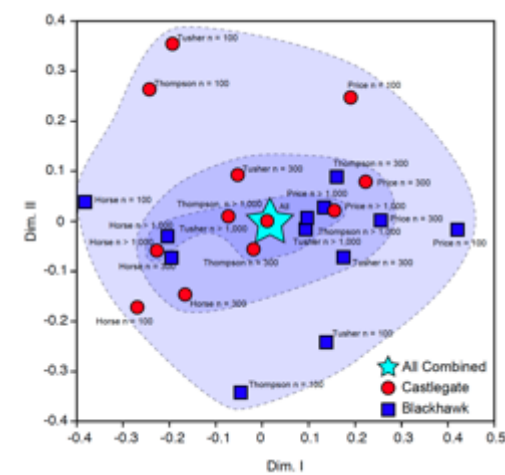


Modified from Pettit et al. (2019)

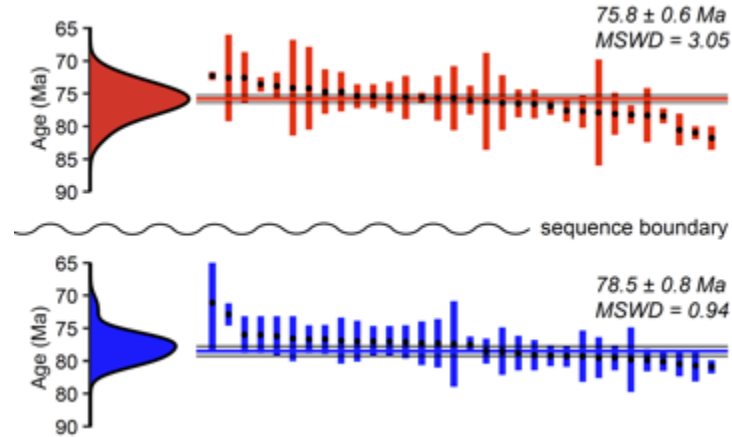


# Conclusions

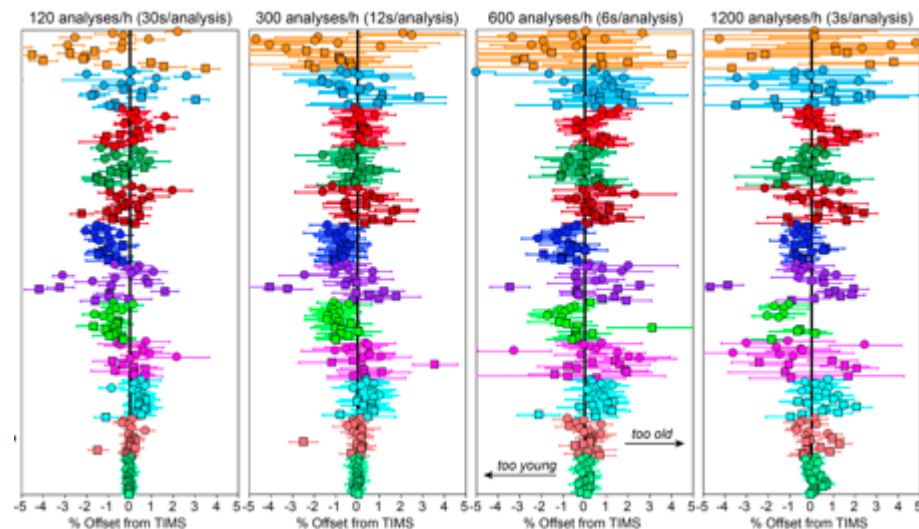
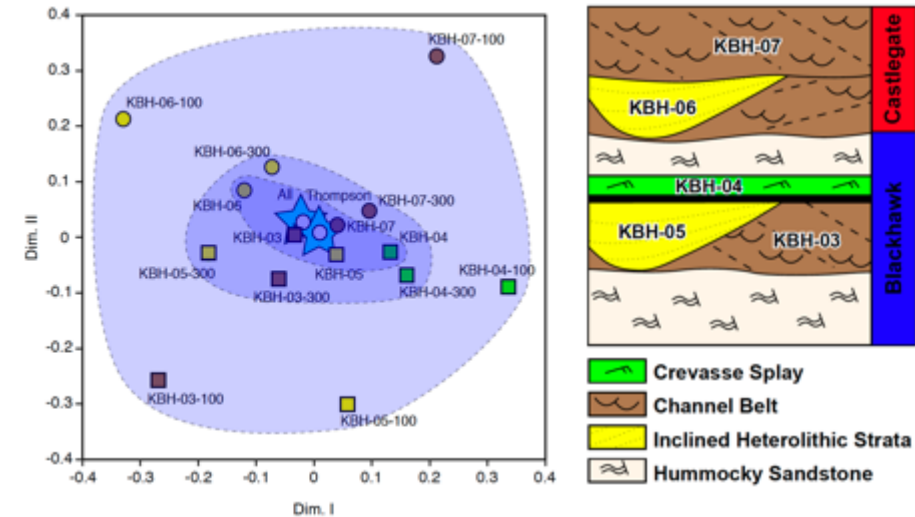
(1) *No provenance changes along or across the Blackhawk-Castlegate sequence boundary*



(2) *By finding young grains we can calculate max depo. ages! ...but what is the best way?*



(3) *Increased sample size reduces lithofacies bias*



*Rapid U-Pb analysis by MC-LA-ICP-MS yields only a minor sacrifice in accuracy and precision*

# Acknowledgements



National Science Foundation

Arizona LaserChron Center: Nicky Giesler, Martin Pepper, Sarah George

Fun and insightful discussions: Joel Saylor, Sebastian Jimenez, Payton McCain, Brook Runyon, Andrew Laskowski, Caden Howlett, and Aislin Reynolds

## *Application of rapid U-Pb acquisition (3 s/analysis) to combat lithofacies bias in detrital zircon age distributions: Example from the Book Cliffs, UT*

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**Mark Pecha**<sup>1</sup>

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