Optical Ages for Deep Last-Glacial Lake Missoula, Montana

Larry N. Smith

Geological Engineering, Montana Tech, 1300 W Park St, Butte, MT 59701

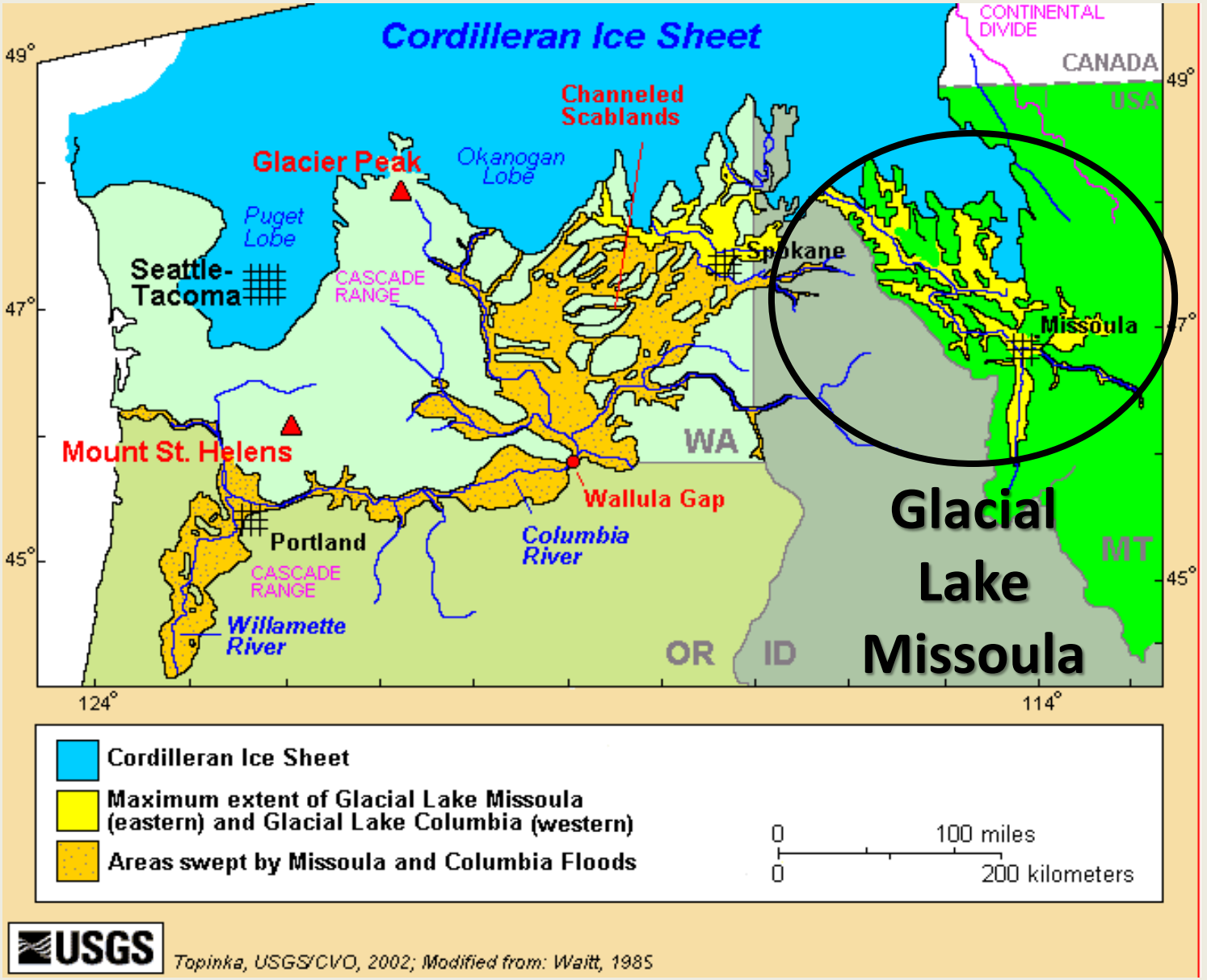
Jan-Pieter Buylaert, Reza Sohbati, Mayank Jain

Center for Nuclear Technologies, Technical University of Denmark, DTU Risø Campus, Roskilde, 4000, Denmark,

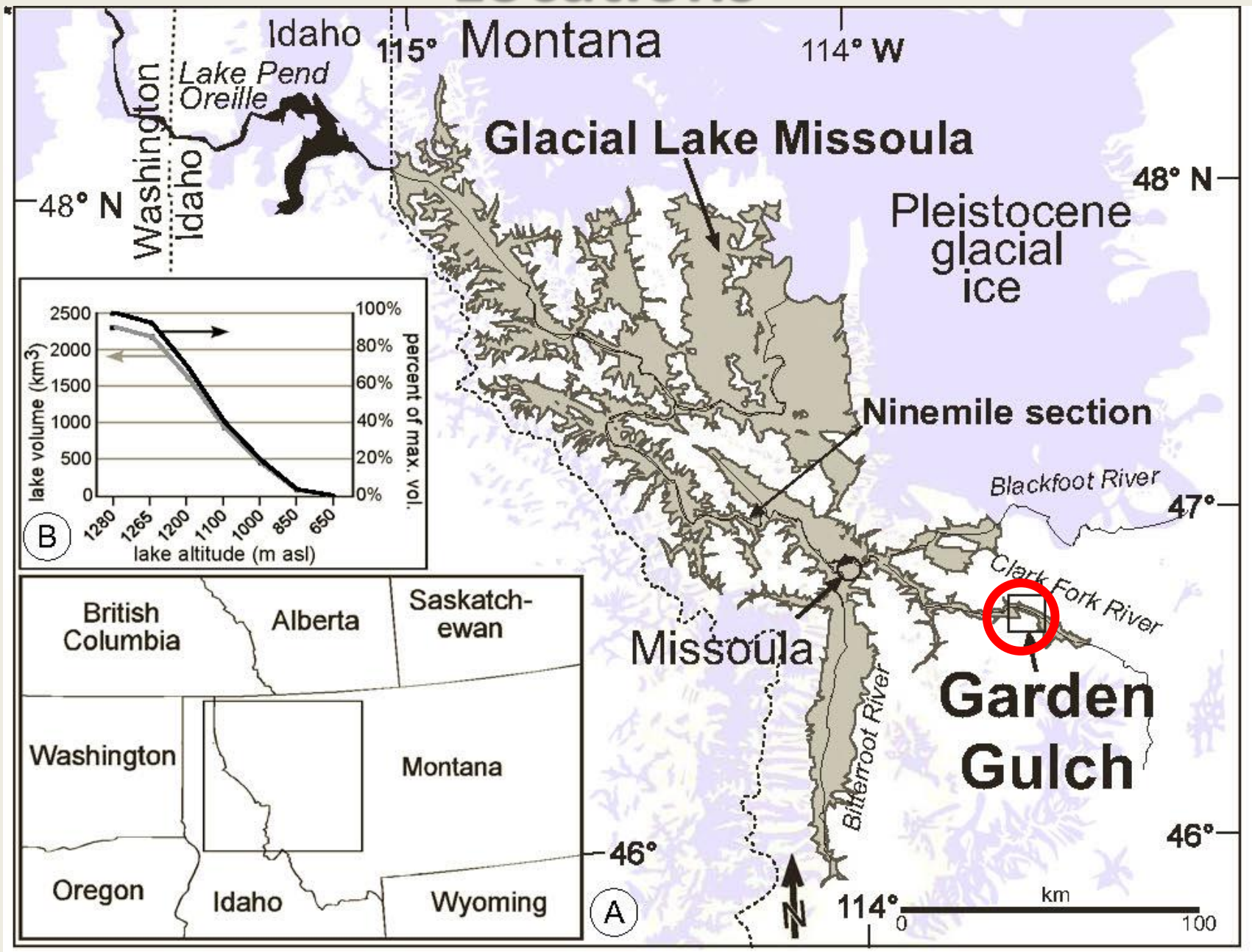
Olav B. Lian

Department of Geography, University of the Fraser Valley

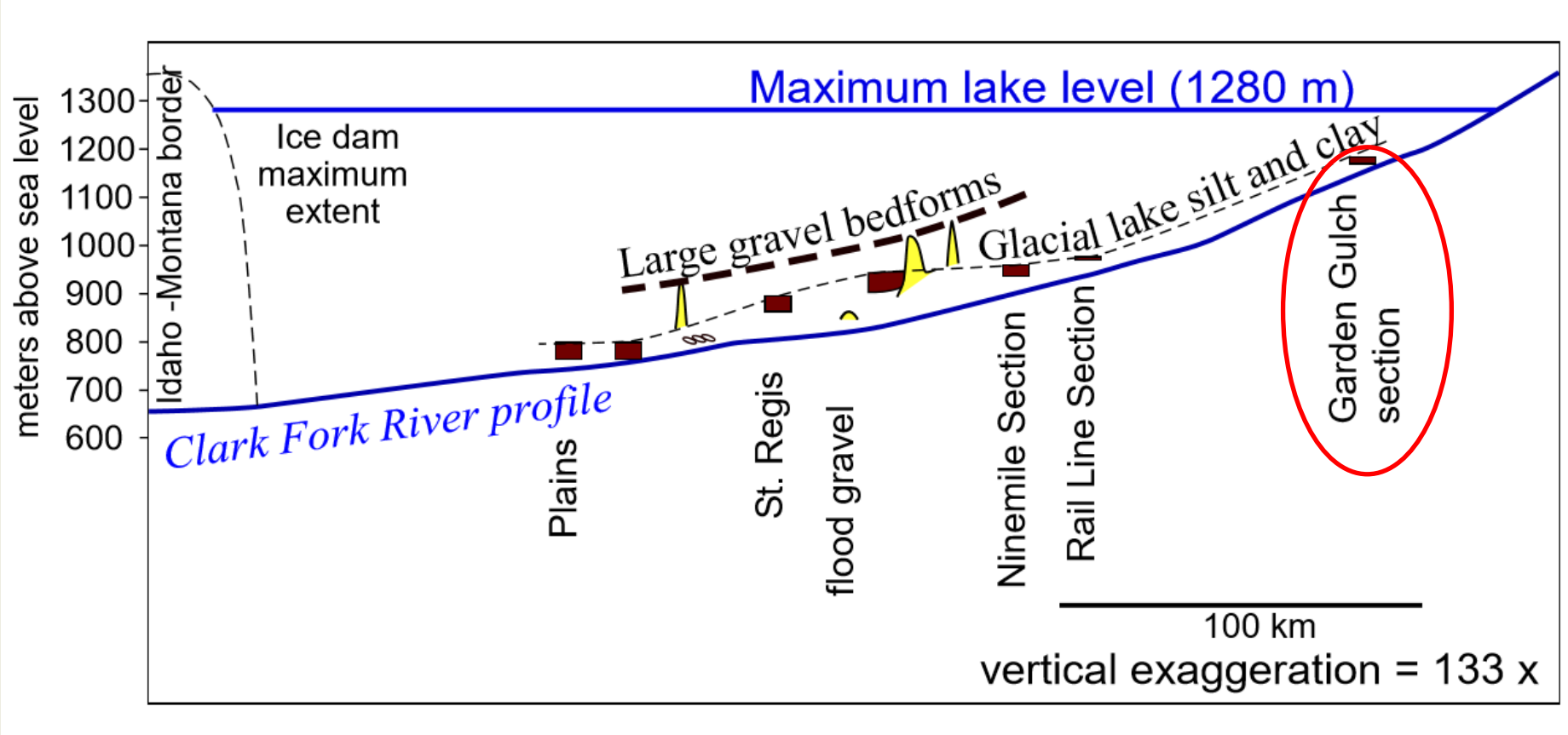
Lakes, Ice, and Scabland System



Locations


Idaho
115°
Montana
114° W
Washington
Idaho
Lake Pend Oreille
48° N
Glacial Lake Missoula
Pleistocene glacial ice
Ninemile section
Blackfoot River
47°
Clark Fork River
Missoula
Bitterroot River
Garden Gulch
46°
114°
km
0
100
N
A
B
lake volume (km3)
2500
2000
1500
1000
500
0
100%
80%
60%
40%
20%
0%
percent of max. vol.
1280
1265
1200
1100
1000
850
650
lake altitude (m asl)
British Columbia
Alberta
Saskatch-ewan
Washington
Montana
Oregon
Idaho
Wyoming
46°

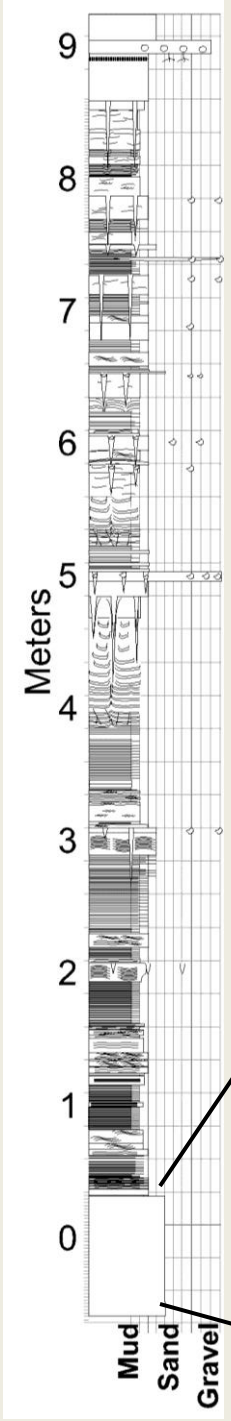
Garden Gulch sediments were deposited when the lake was ≥ 65% capacity



“Garden Gulch” Section

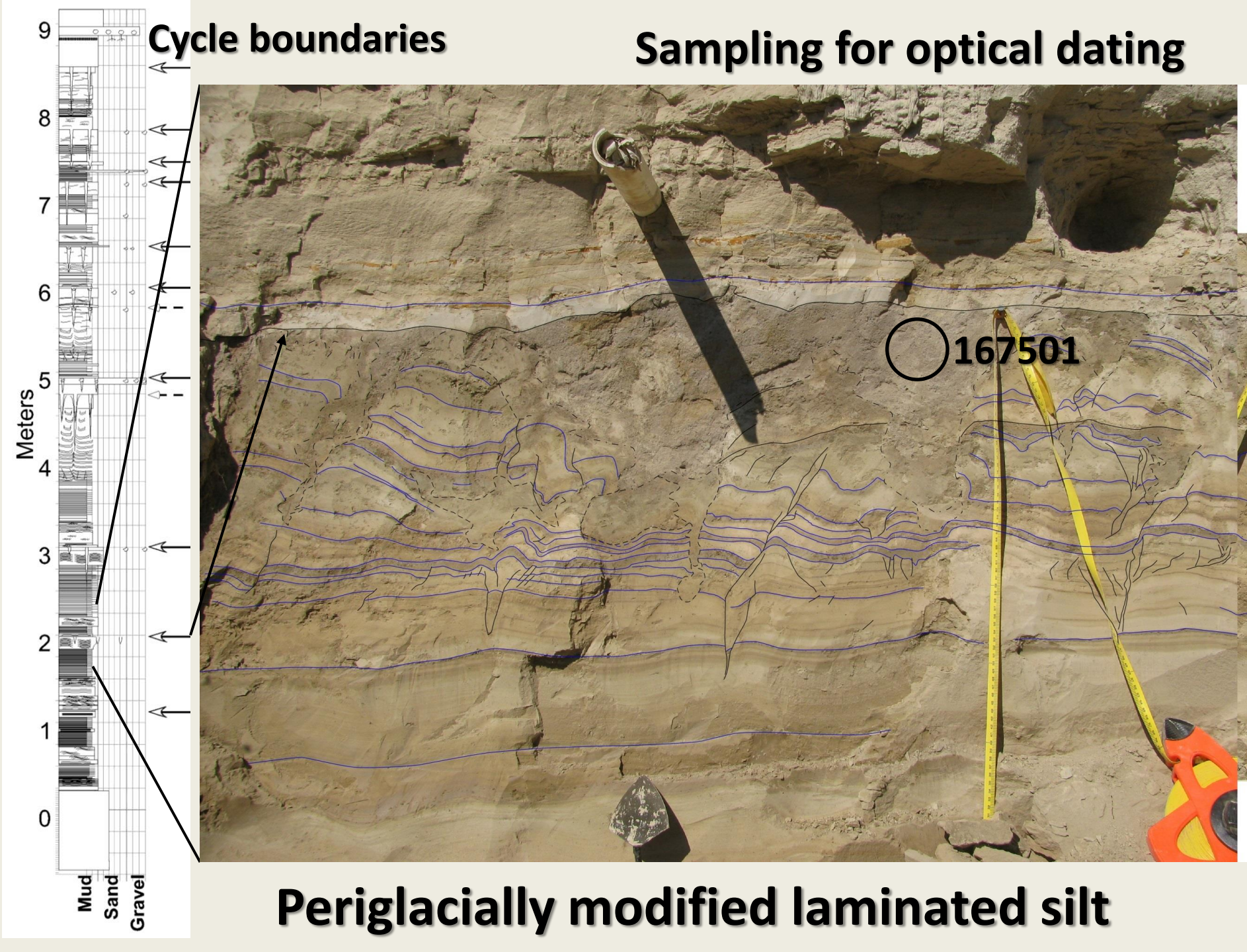
Garden Gulch section

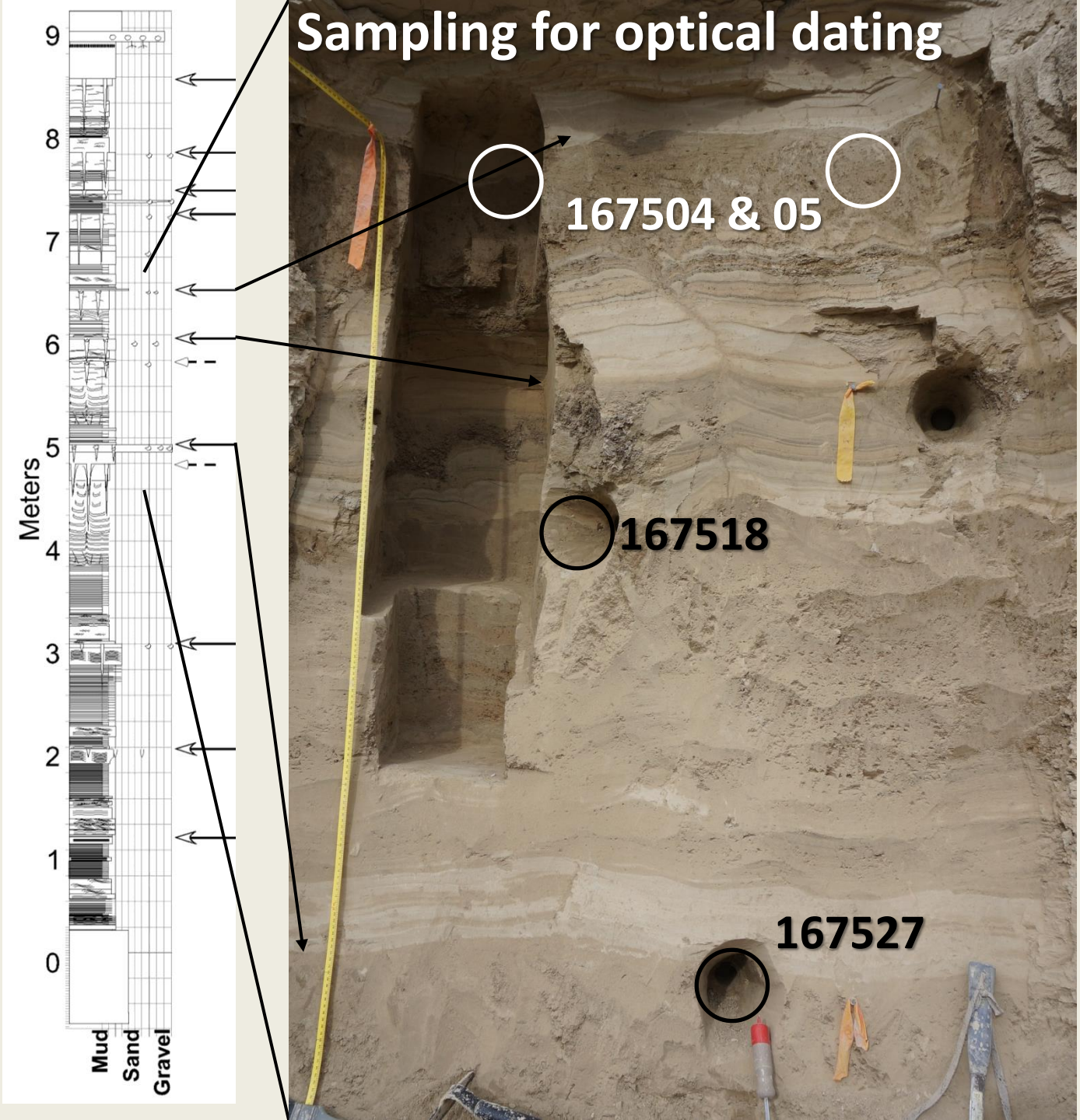
Sampling for optical dating



Rhythmically laminated silt

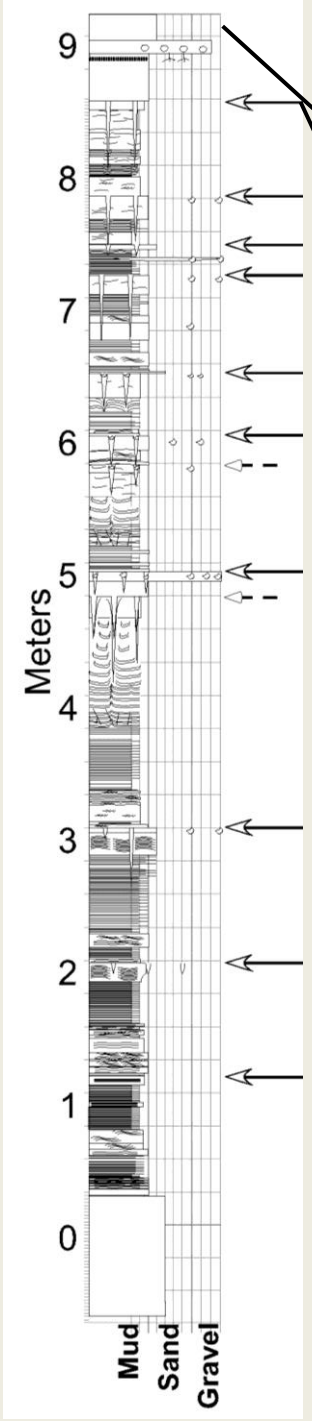
Basal sand


Cycle boundaries
Sampling for optical dating
167501
Meters
0
1
2
3
4
5
6
7
8
9
Mud
Sand
Gravel
Periglacially modified laminated silt



Periglacially modified laminated silt, downward-tapering wedges of sand and gravel

Sampling for optical dating



Weak soil structure and $CaCO_3$ cement

Upper limit of glaciolacustrine (burrowed)

Purified Quartz & K-rich feldspar sample preparation

- Wet sieve for 180-250 micron fraction
- Acid cleaning with 10% HCL & organic matter removal with H_2O_2
- Heavy liquid separation (2.58 g cm-1)
- Etching of quartz 40% HF & feldspar in 10% HF
- Quartz purity tested using infrared (IR) stimulation
  - Some quartz samples etched again with 40% HF

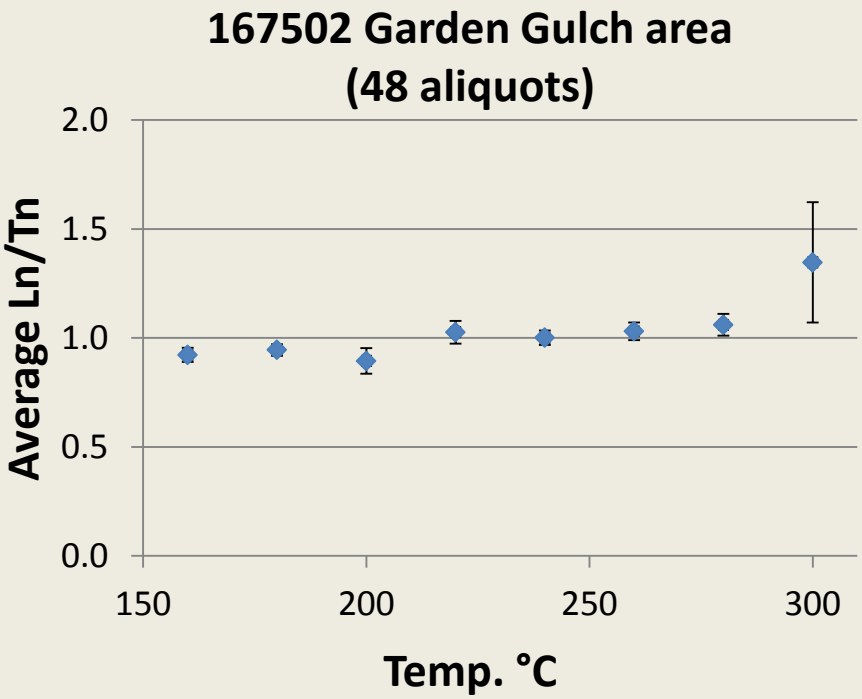
Multi-grain OSL measurements

- TL/OSL Risø DA-10, DA-15, and DA-20 readers
- Blue (470 ± 30 nm) & infrared (IR 870 ± 40 nm) stimulation LEDs
- Detection of quartz signal through UV filters
- Large aliquot (5-8 mm stainless steel cups) appropriate for late Pleistocene samples*

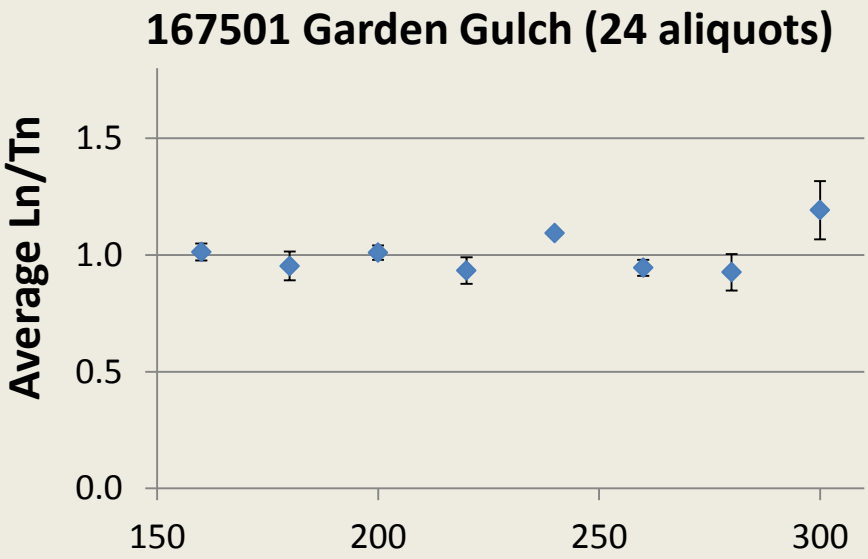
* Murray et al. (2015) Radiation Measurements and Thomsen et al. (2016) Quaternary Geochronology

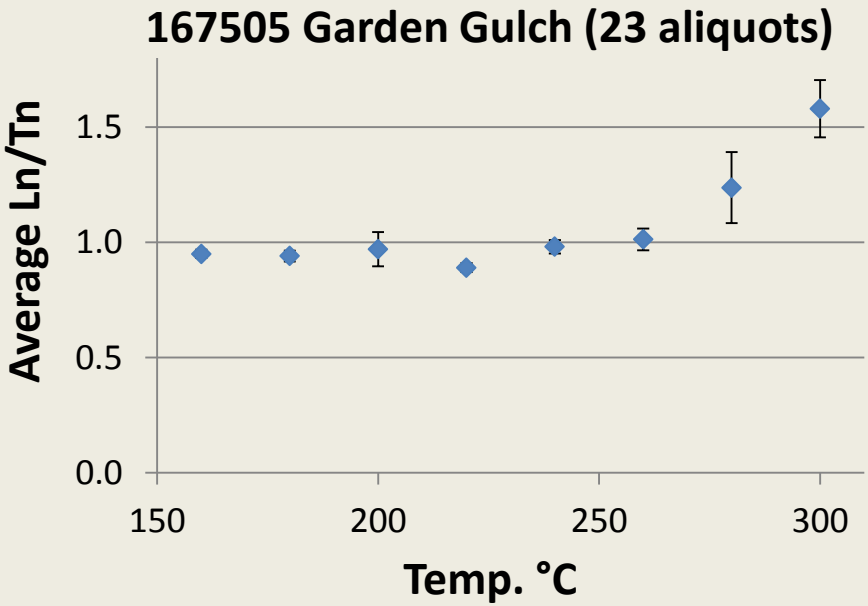
Preheat Plateau tests

Basal Sand

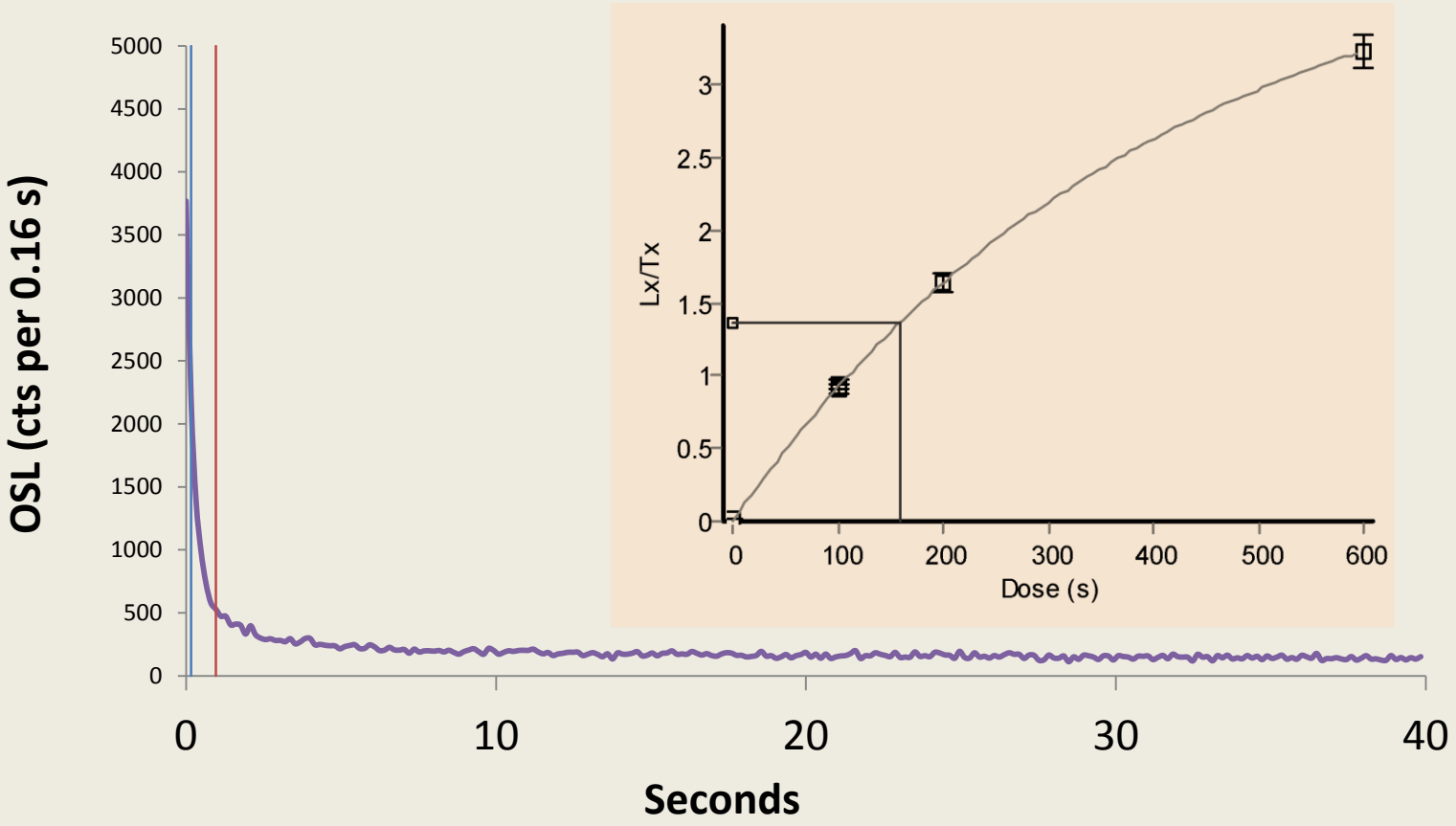


Sand in periglacial wedges





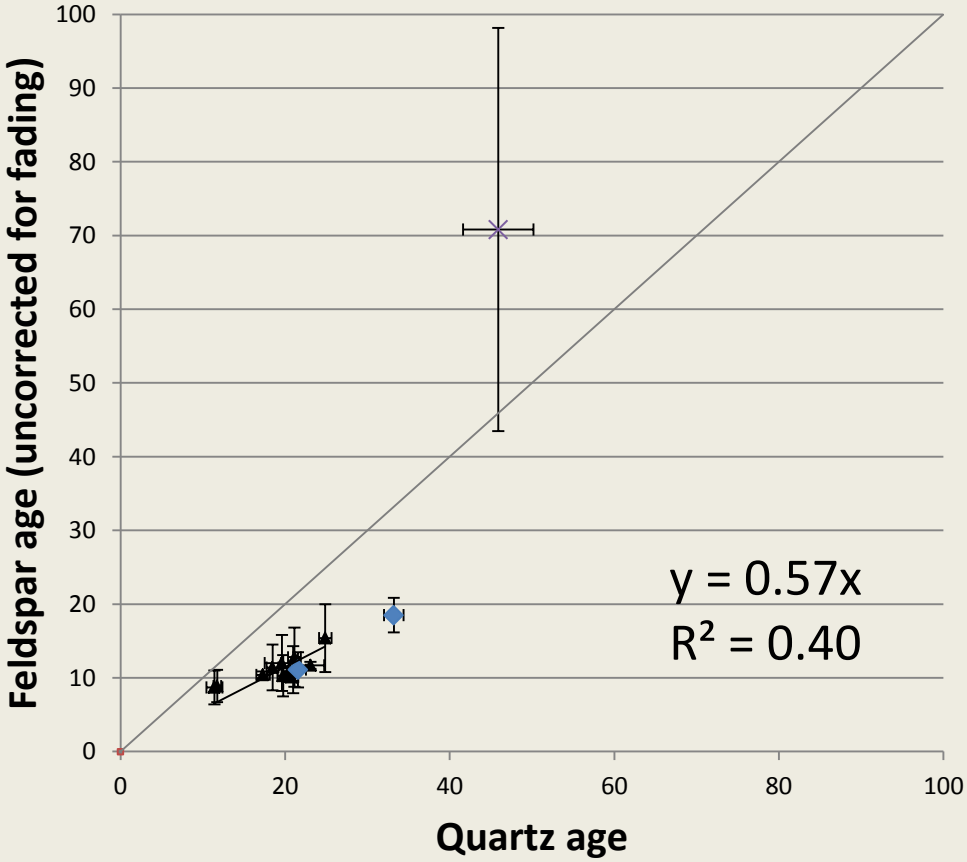
Signal measured with early background subtraction



Test for Quartz bleaching

- Comparison of Quartz ages to K-Feldspar ages
  - 13 samples with data
- Most Feldspar ages are ~60% of Quartz ages
- Quartz bleaches in sunlight much more readily
- Therefore lower uncorrected Feldspar ages show Quartz is likely well bleached

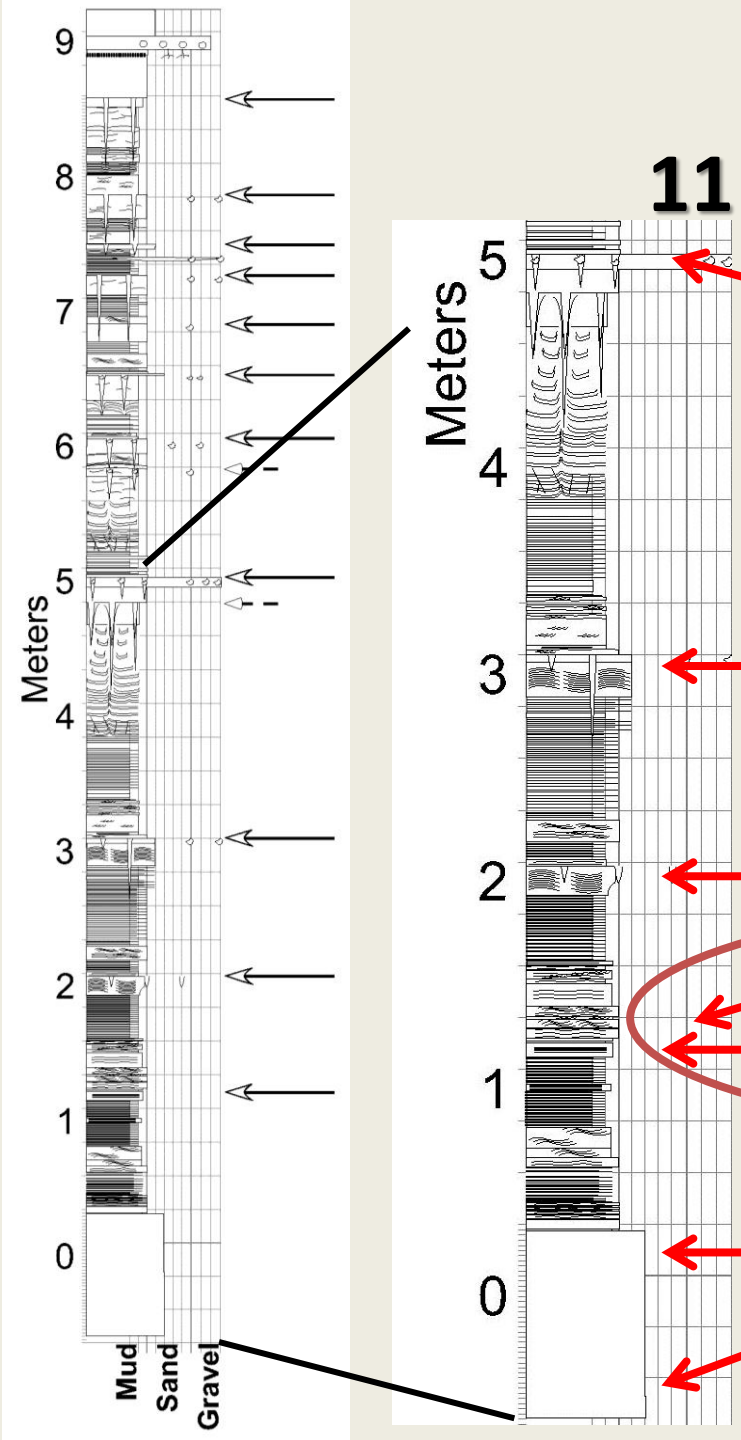
  (Murray et al., 2012)
- One sample has old ages and likely poorly bleached



Dose rate measurements

- Two dose rate samples were prepared for each sample
  - From extra material in tube
  - From ~30 cm diameter around tube to sample heterogeneous layers
- 100-250 g sample crushed and cast with wax for cups measured after 20 days to equilbrate ^{222}Rn and ^{226}Ra
- High-precision gamma spectroscopy
- Conversion factors of Guerin et al. (2011)
- Tube data were used for Beta dose calculations
- Averaged data were used for Gamma dose calculations

Garden Gulch section:
11 exposure surfaces, 15 samples



167527 19.8±2.4 ka **(14/15)**

167503 22.3±1.8 ka **(20/26 aqts)**

167519 21.0±1.3 ka **(22/24 aqts)**

167501 20.0±1.4 ka **(24/27)**

167520 47.8± 5 ka **(24/25)**

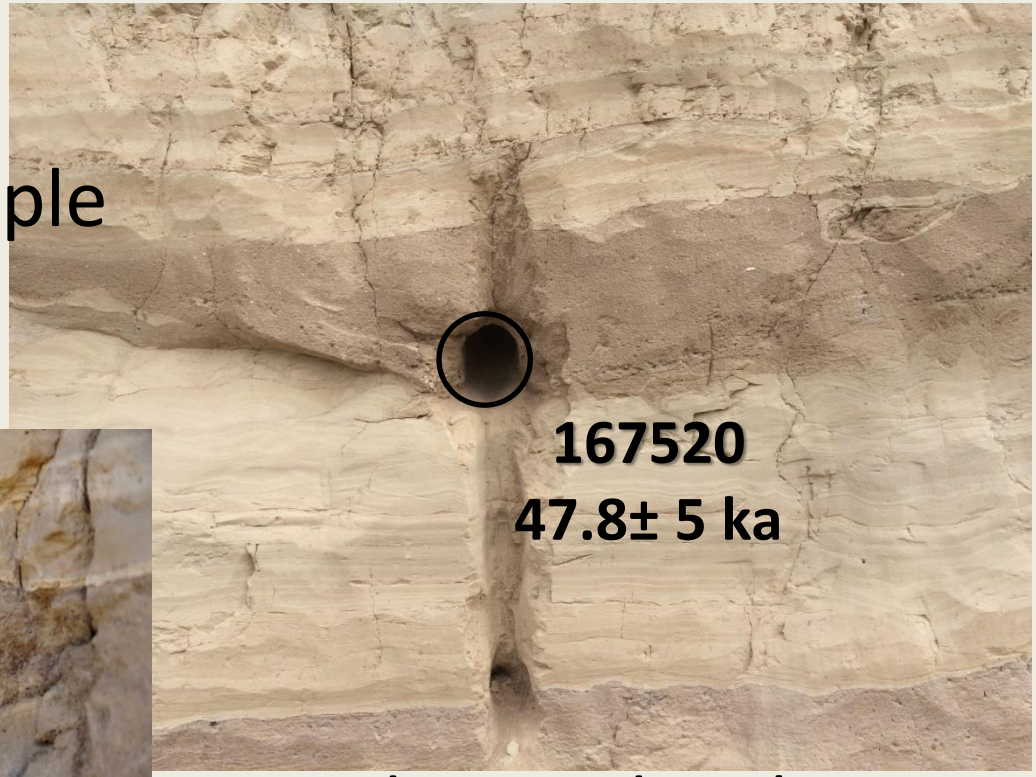
167516 24.8±1.7 ka **(23/26)**

167502 22.7±2.4 ka **(15/24)**

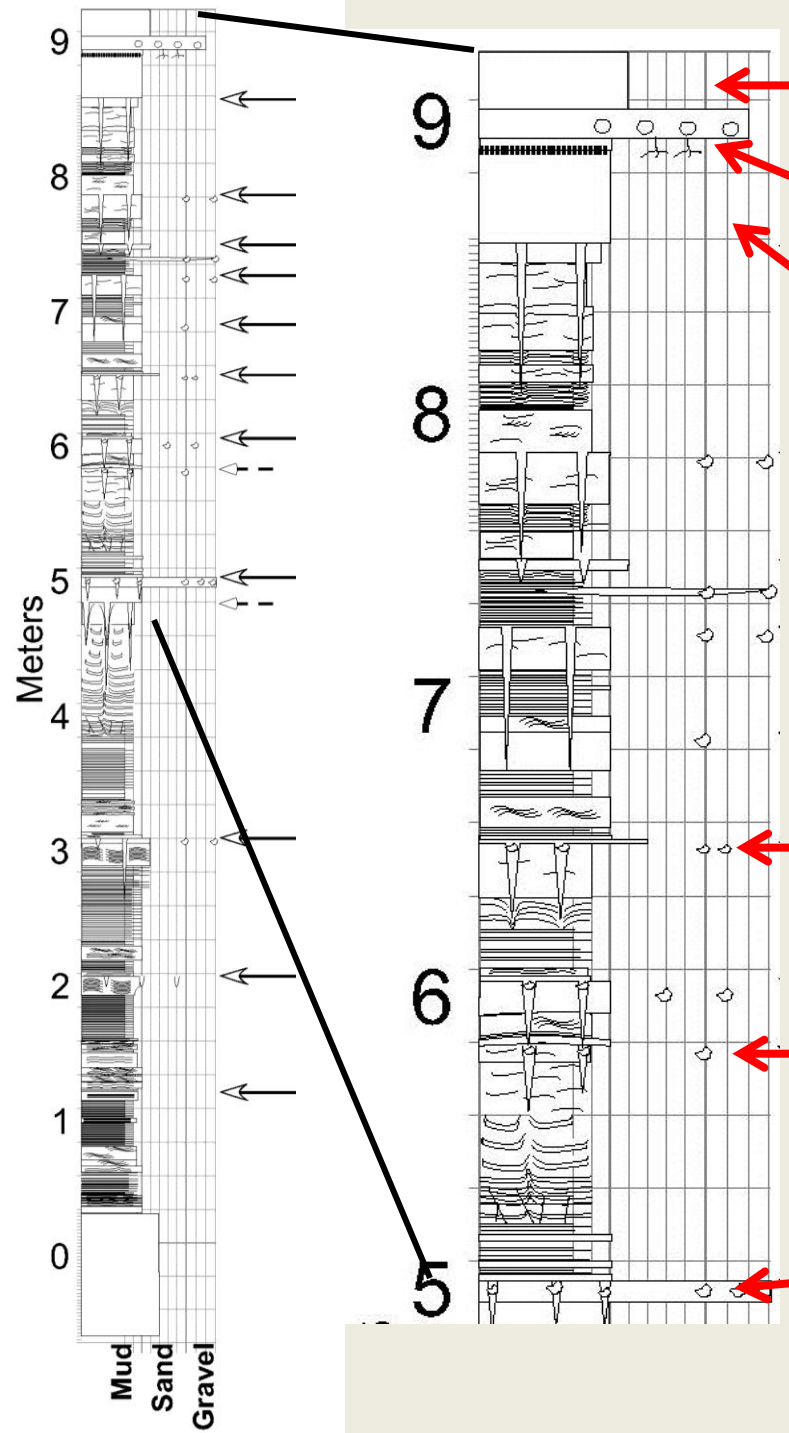
167521 18.8±1.8 ka **(14/15)**

Top of cycle 1

- Sand with upward injection structures
- 47.8±5 ka age
- Poorly bleached sample



- Sand immediately below
- 24.8±1.7 ka age
- Mix of sands?



UFV JD-3 10.5±0.6ka (38)

167511 11.4±1.2ka (20/21)

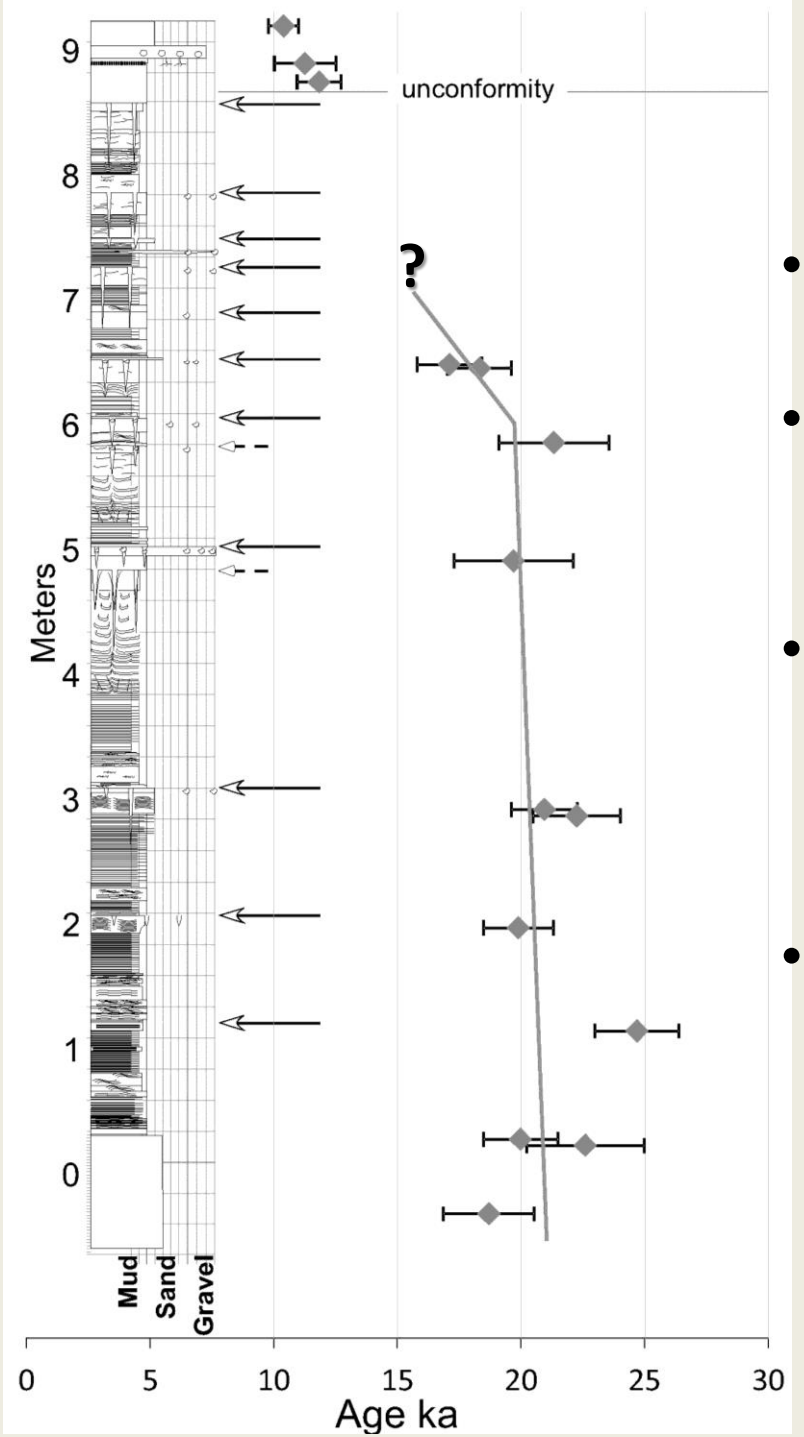
167522 11.9±0.9ka (14/18)

167504 17.2±1.3ka (19/20)

167505 18.4±1.3 ka (21/22)

167518 21.4±2.1 ka (14/18)

167527 19.8±2.4 ka (14/15)



Conclusions

- Lake filled to >65% of capacity about 11 times from ~21,000 - <17,200 yr
- More fluctuations in level occurred before drainage before Glacier Peak G tephra (13,710-13,410 yr)
- Documents fluctuations of lake level and/or drainings
  - *No direct evidence for high-velocity currents*
- Draining from one or more of these deep-lake stands drainage may be responsible for big early floods (10-17 million m^3/sec)*

* Benito and O'Connor (2003) *GSA Bulletin*
Alho et al. (2010) *Quaternary Science Reviews*