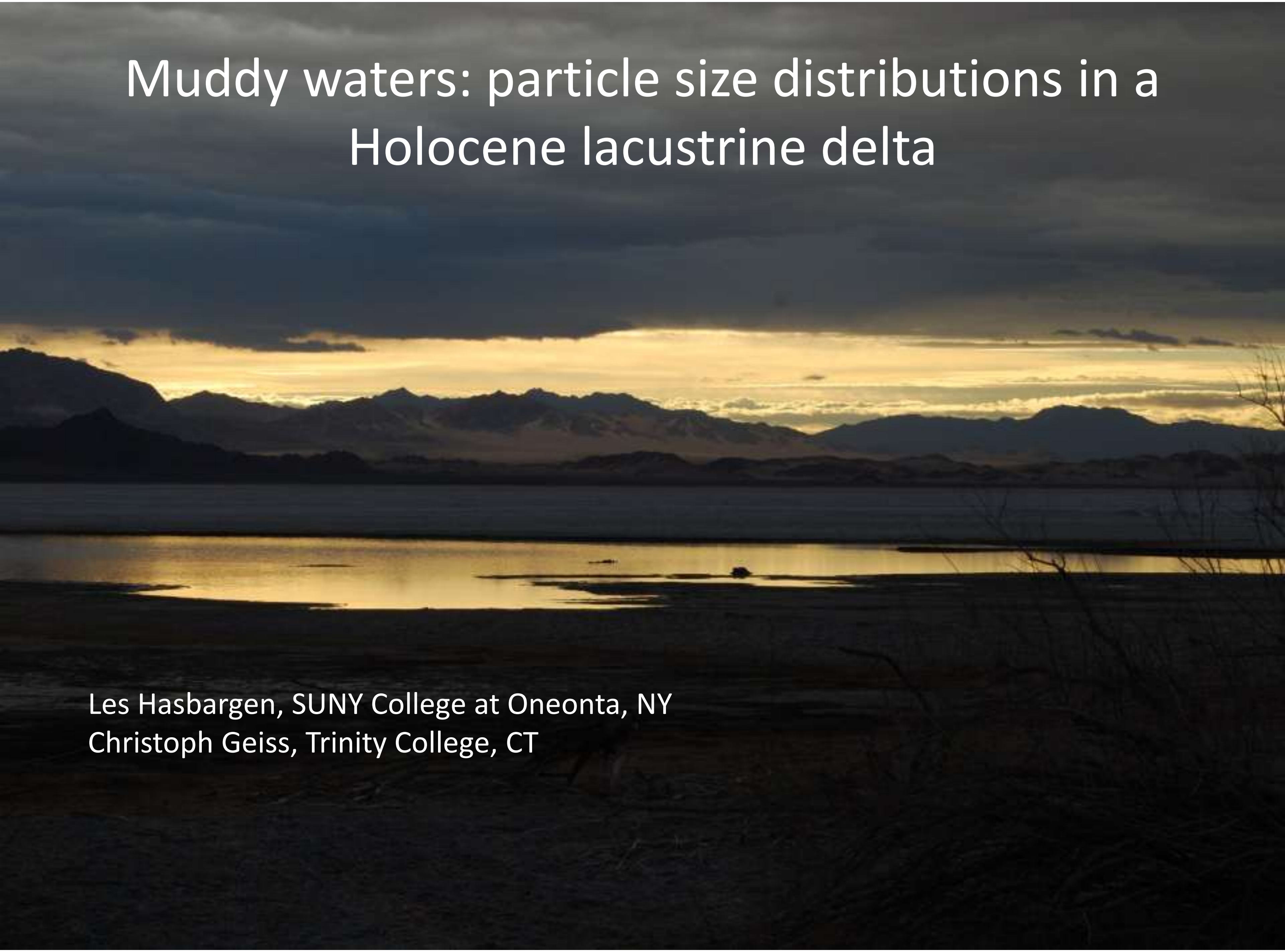
Muddy waters: particle size distributions in a Holocene lacustrine delta



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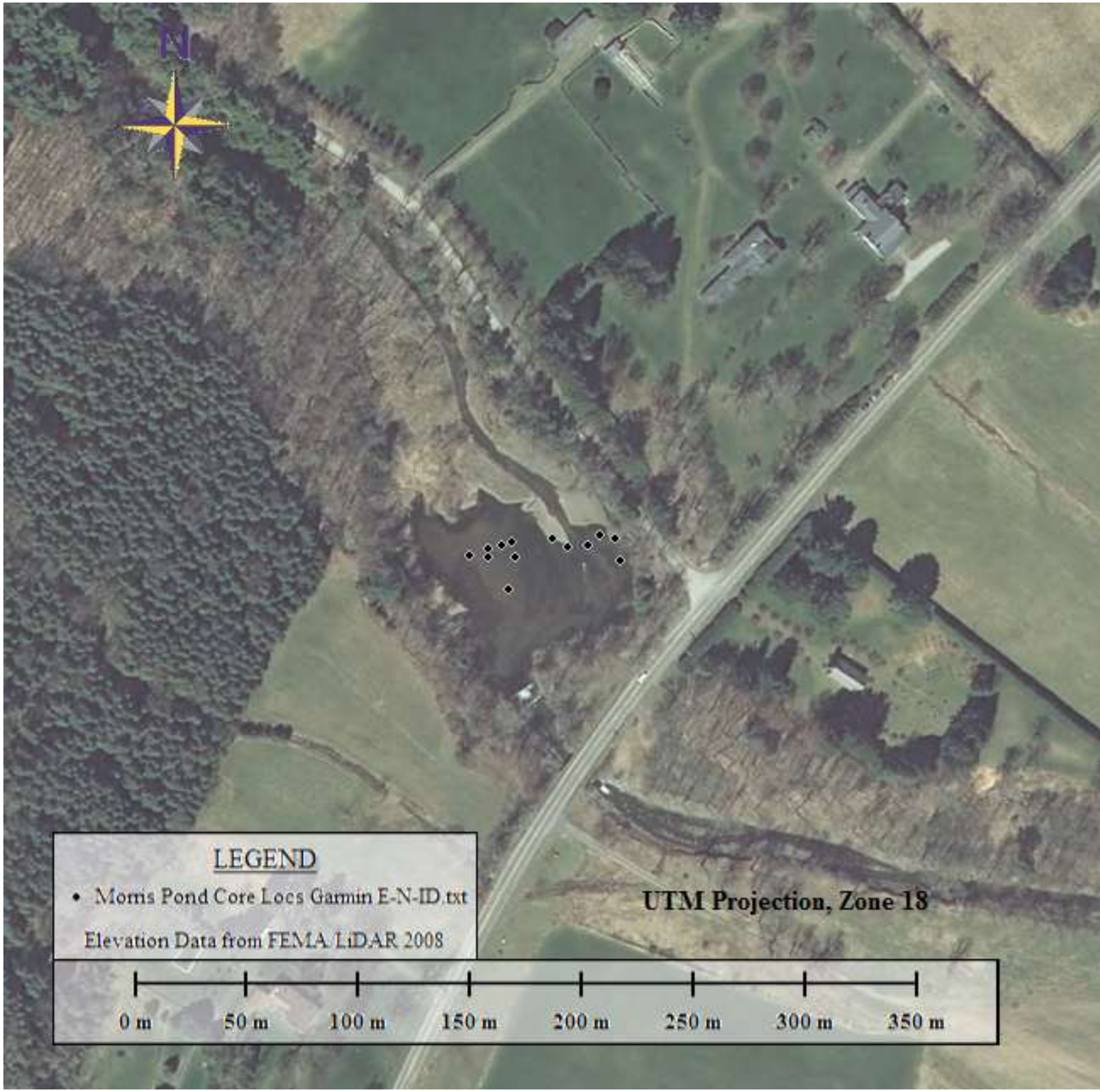
Christoph Geiss, Trinity College, CT

Muds and Floods

- **Goal**: Use grain size in muddy lake and reservoir deposits to reconstruct flood records
- **Goal**: Characterize historic sediment flux into reservoirs
- This Project presents:
  - At a glance, size variation on local deltas is huge
  - At a glance, size variation in muds/gravels is large
  - At a glance, deposition across delta is stochastic
  - Not so clear: moving farther from the delta, do muds change in grain size?
  - Is there a meaningful, relatively simple way to measure 1 to 50 μm size particles?


Delta Front

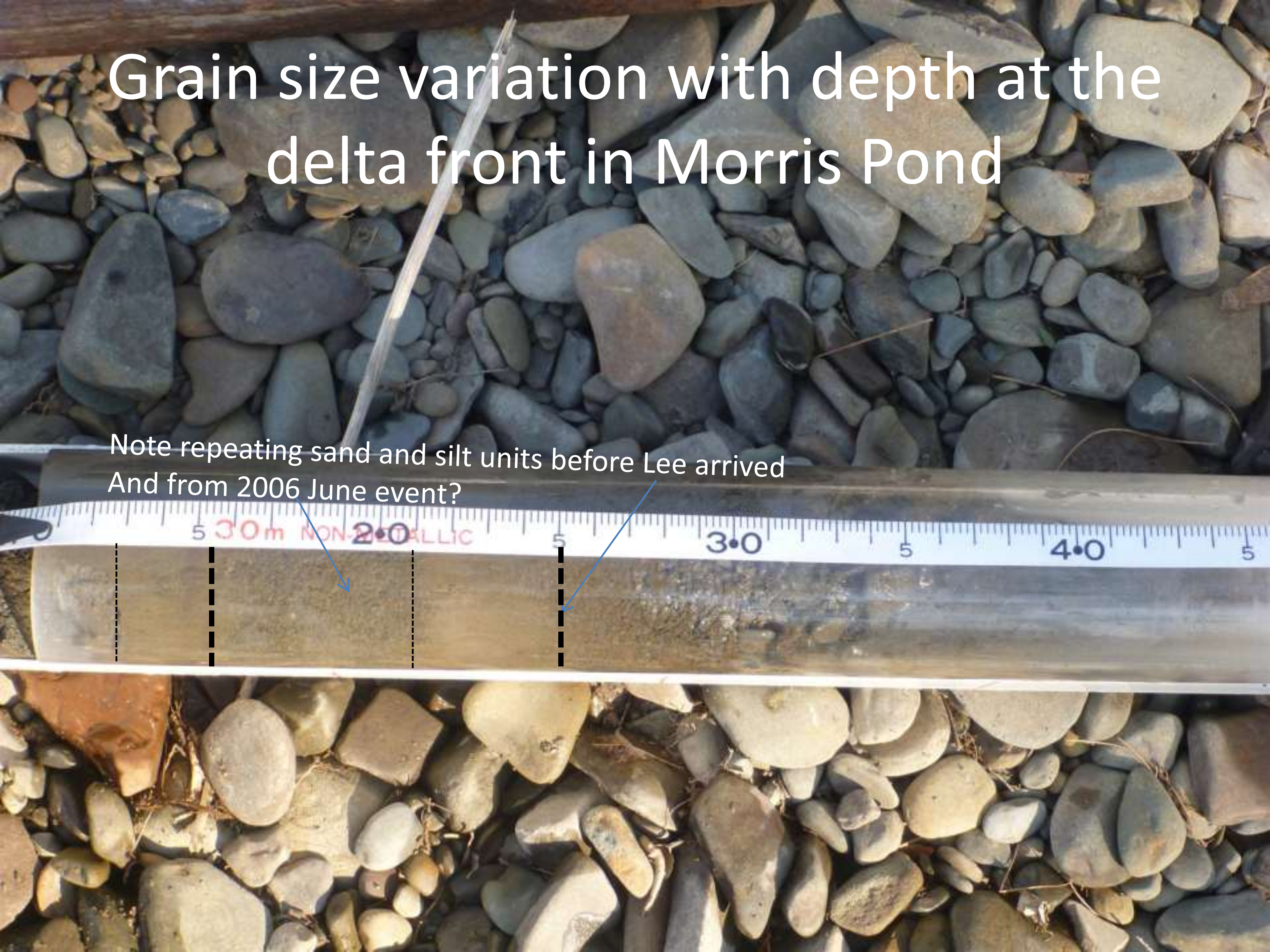


Morris Pond with sediment core locations (at current delta front). Advance of delta front occurred in Sept. 2011.

Morris Pond, Morris, NY: runoff from Lee Sept. 2011


Delta Front, Morris Pond, March 2012
Abrupt cobble/sand transition

Grain size variation with depth at the delta front in Morris Pond

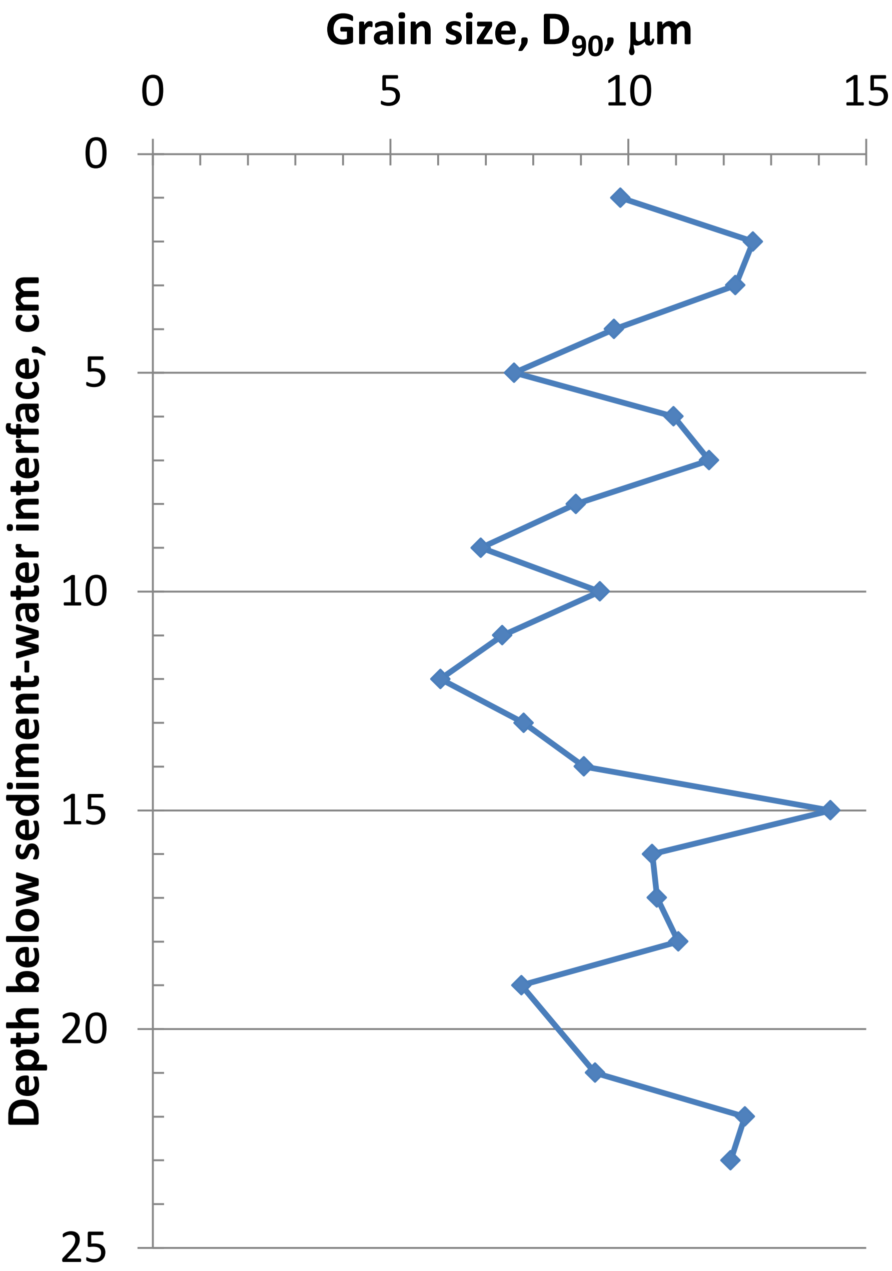


Grain size measurements

- Visual with a scale—ok for gravel
- Photomicrographs offer distributions
- Grain size variation with depth at Otsego Lake
- Grain size distributions for mud
  - Size distribution varies between plane and cross polarized light (target silicate detrital grains)
  - Sample size considerations
  - Power law distributions

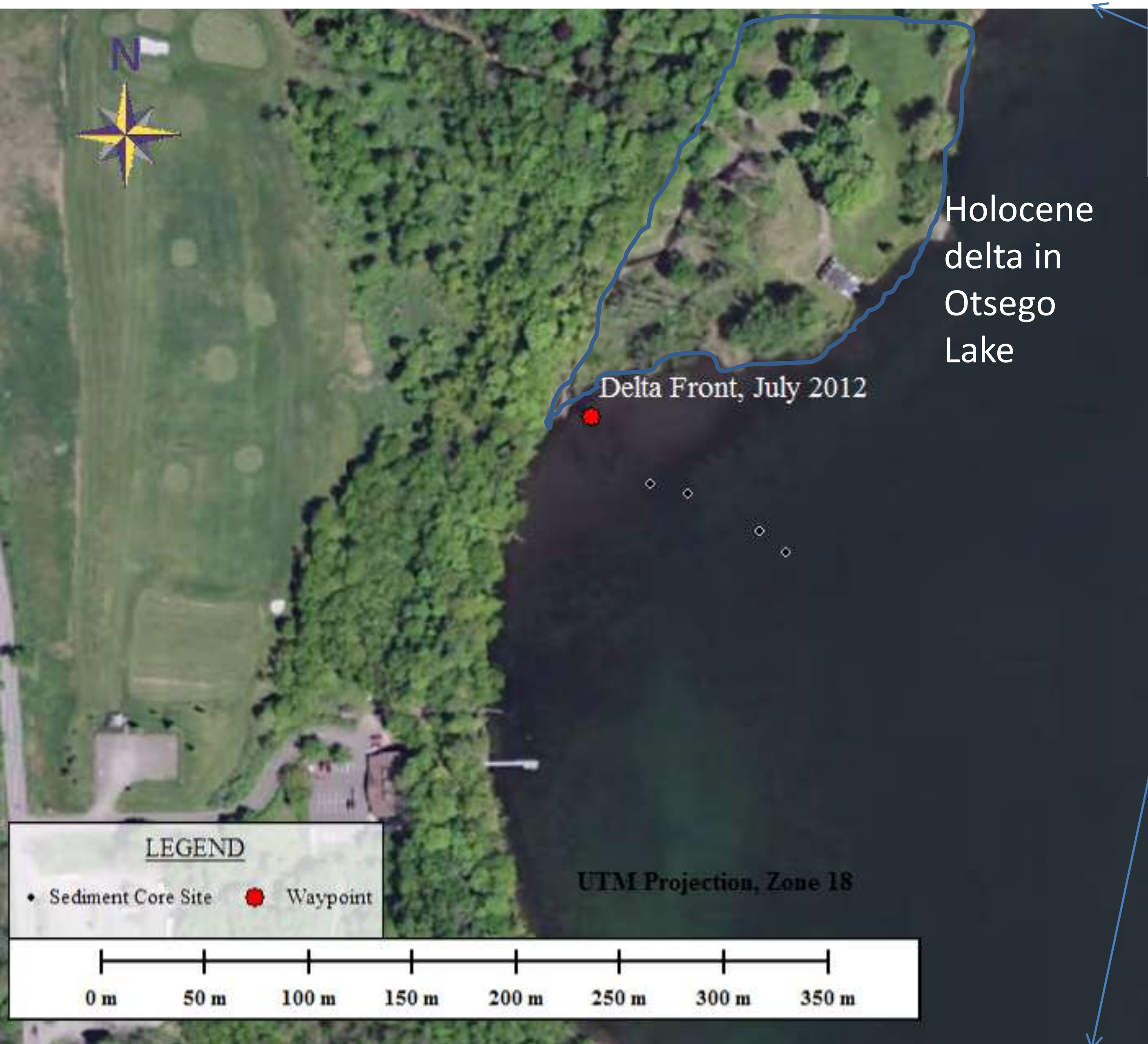
Sampling Procedure

- Small sample by toothpick from core to glass slide, glue cover slip, and label slide
- Photomicrograph at 10X magnification
  - Collect several photos of each slide for plane and cross polarized light
- Run particle size macro in ImageJ (scale, threshold, identify shapes, measure…)
- Extract statistics on shape
  - Use Minimum Feret diameter as intermediate grain diameter



Grain size variations in Morris Pond, just off the delta front, single core

Distal delta cores show repetitive grain size variations, with leaf layers (white arrows) Morris Pond



Otsego Lake sediment core locations. Advance of delta front occurred in Sept. 2011.

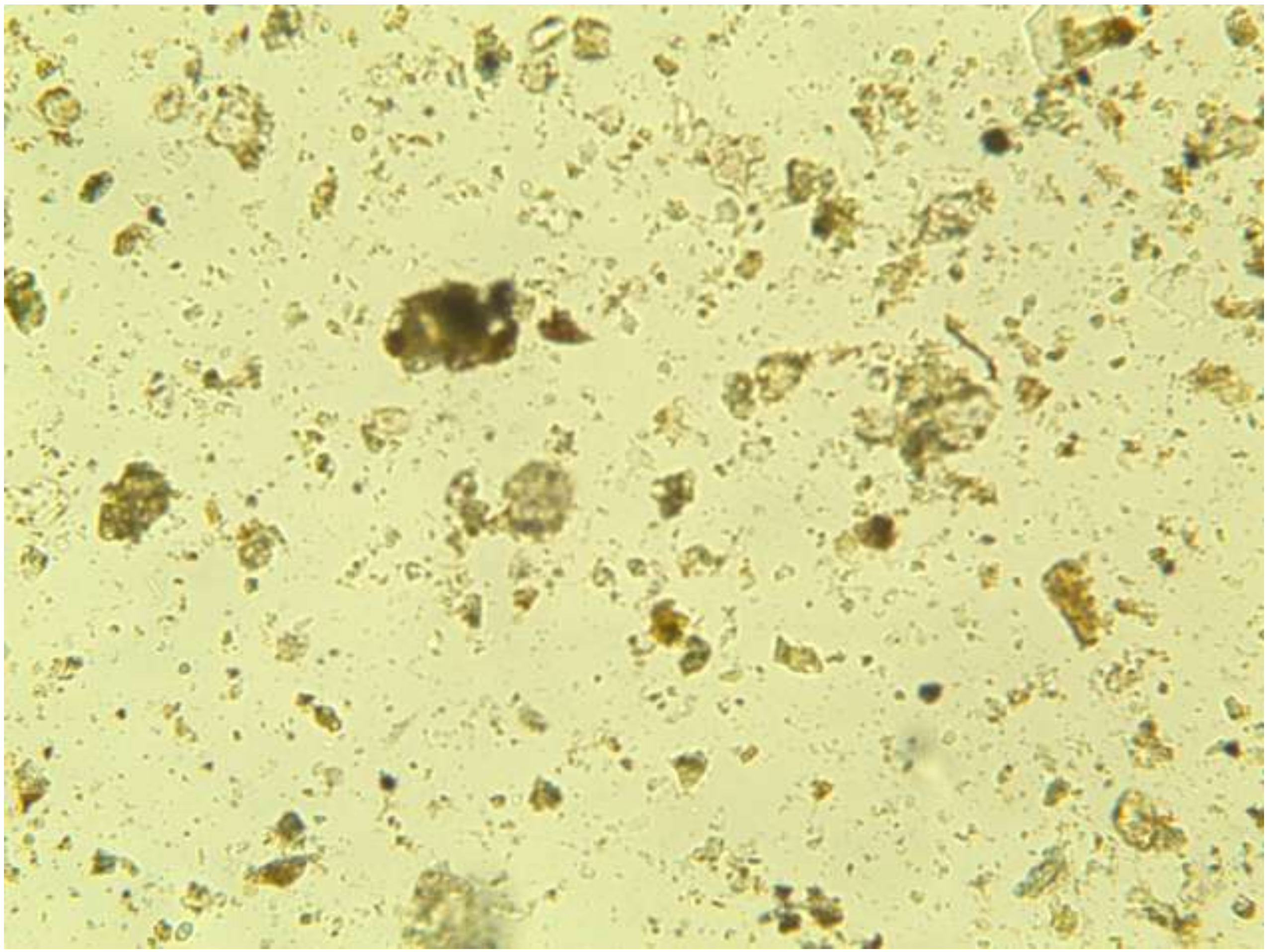
Otsego Lake, NY


Otsego Lake
Delta topsets

Proximal to distal cores, Otsego Lake

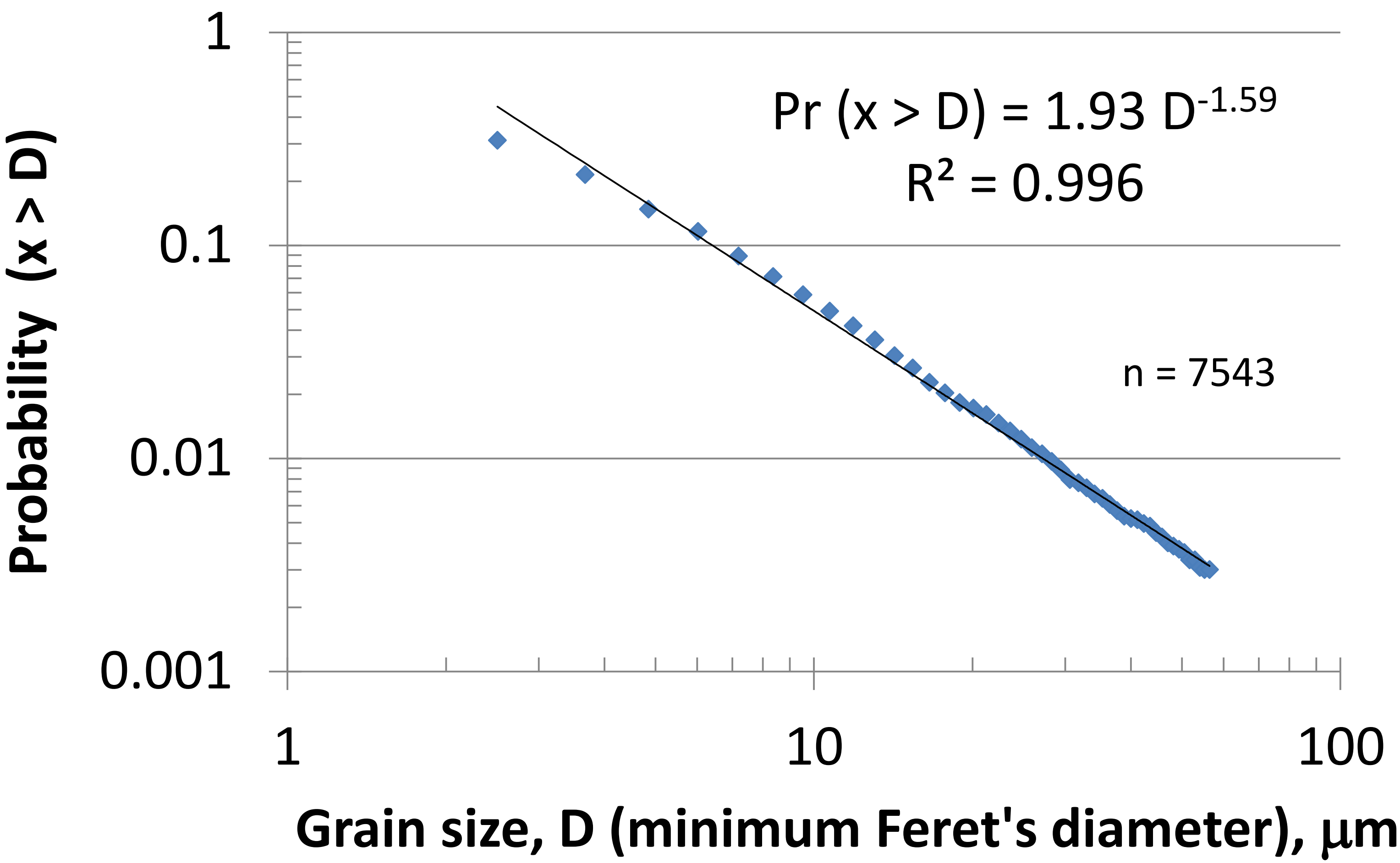
OTS-12-05-12C

Example of Sediment Micrograph
Plane Polarized Light

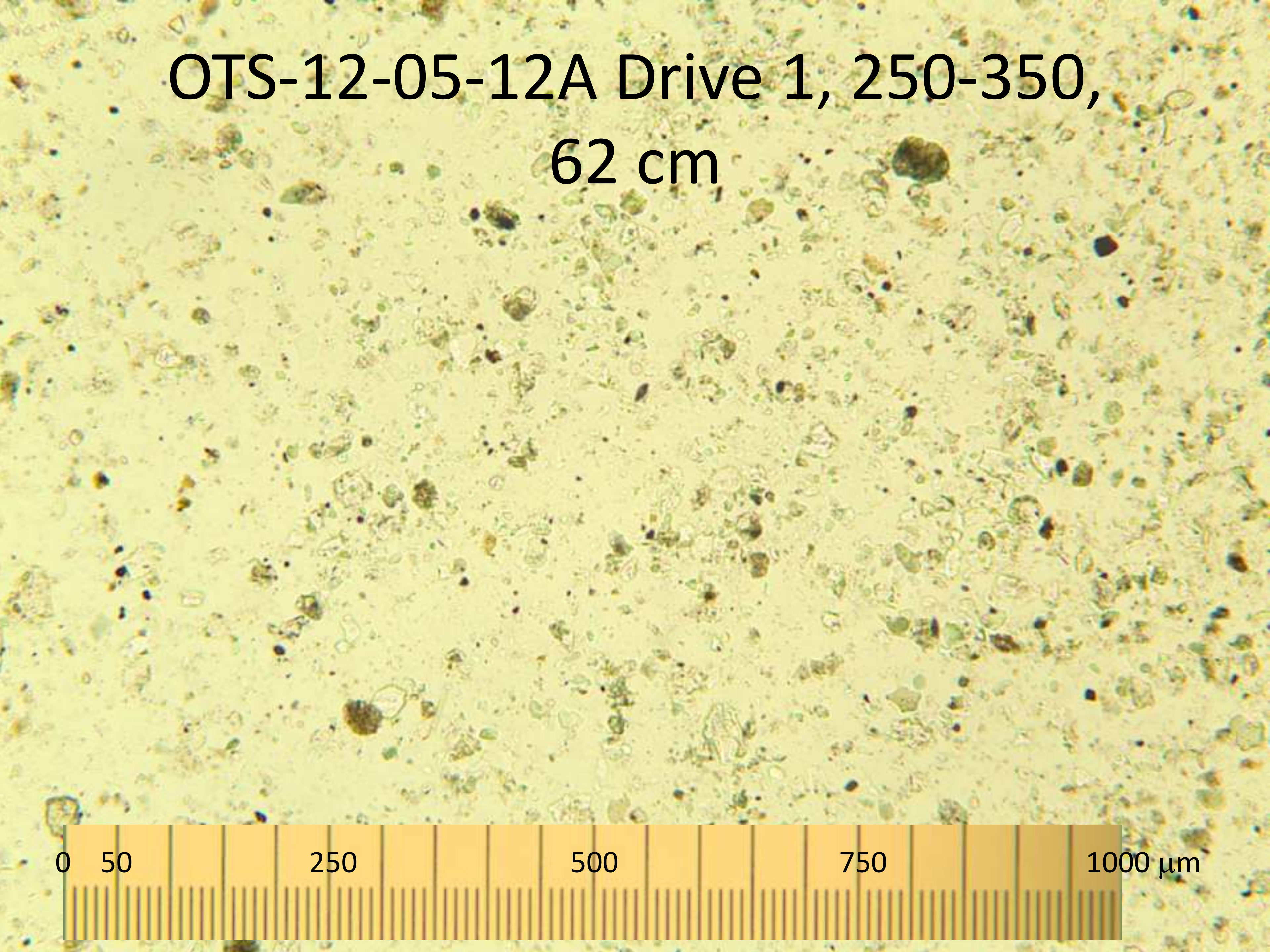


0 100 microns (1.3 pixels/micron)

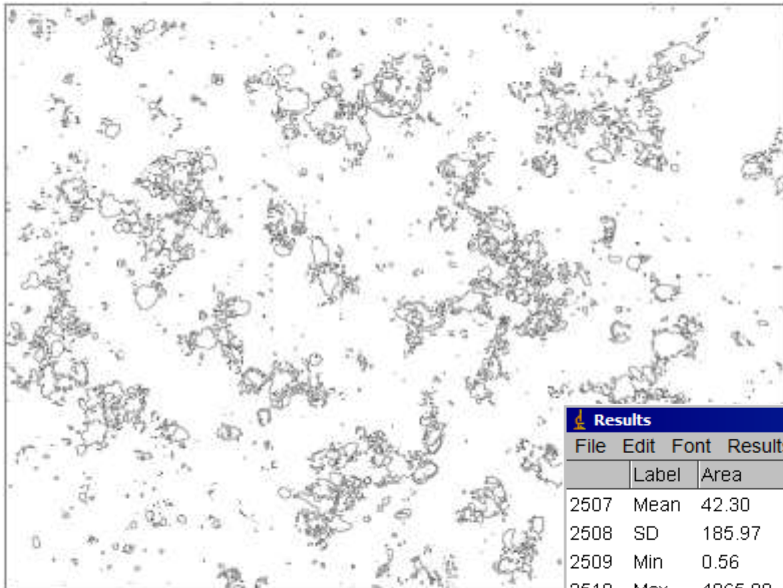
An Example Grain Size Distribution



OTS-12-05-12A Drive 1, 250-350, 62 cm



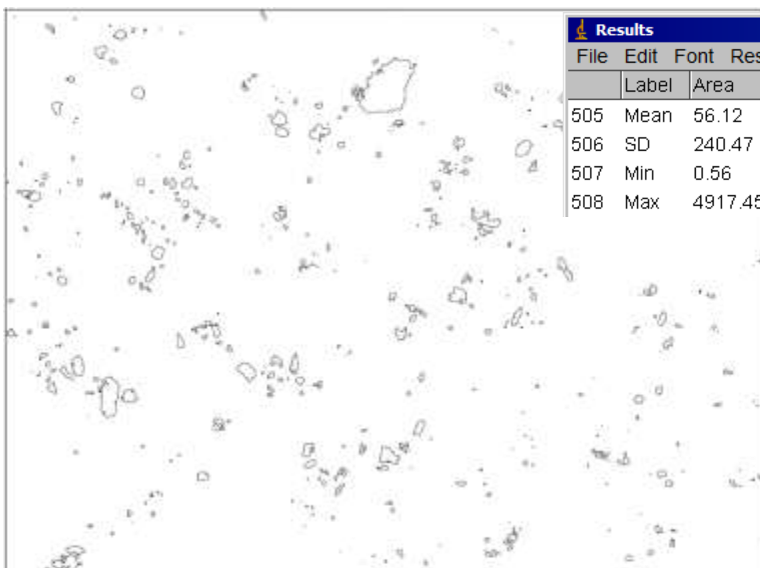
Grain shapes auto-delimited by ImageJ for Plane (top) and Cross (bottom) Polarized Micrographs



Results

File Edit Font Results

	Label	Area	Major	Minor	Angle	Circ.	Feret	FeretX	FeretY	FeretAngle	MinFeret	AR	Round	Solidity
2507	Mean	42.30	5.95	3.27	73.20	0.78	7.17	578.57	460.31	106.95	4.11	1.89	0.62	0.83
2508	SD	185.97	8.03	4.65	59.19	0.26	10.60	329.31	240.79	46.60	6.61	0.82	0.22	0.14
2509	Min	0.56	0.85	0.72	0	0.04	1.06	2.25	4.50	2.15	0.75	1	0.13	0.27
2510	Max	4065.00	92.59	57.93	180.00	1	120.00	1196.39	896.55	176.99	91.50	7.47	1.00	1

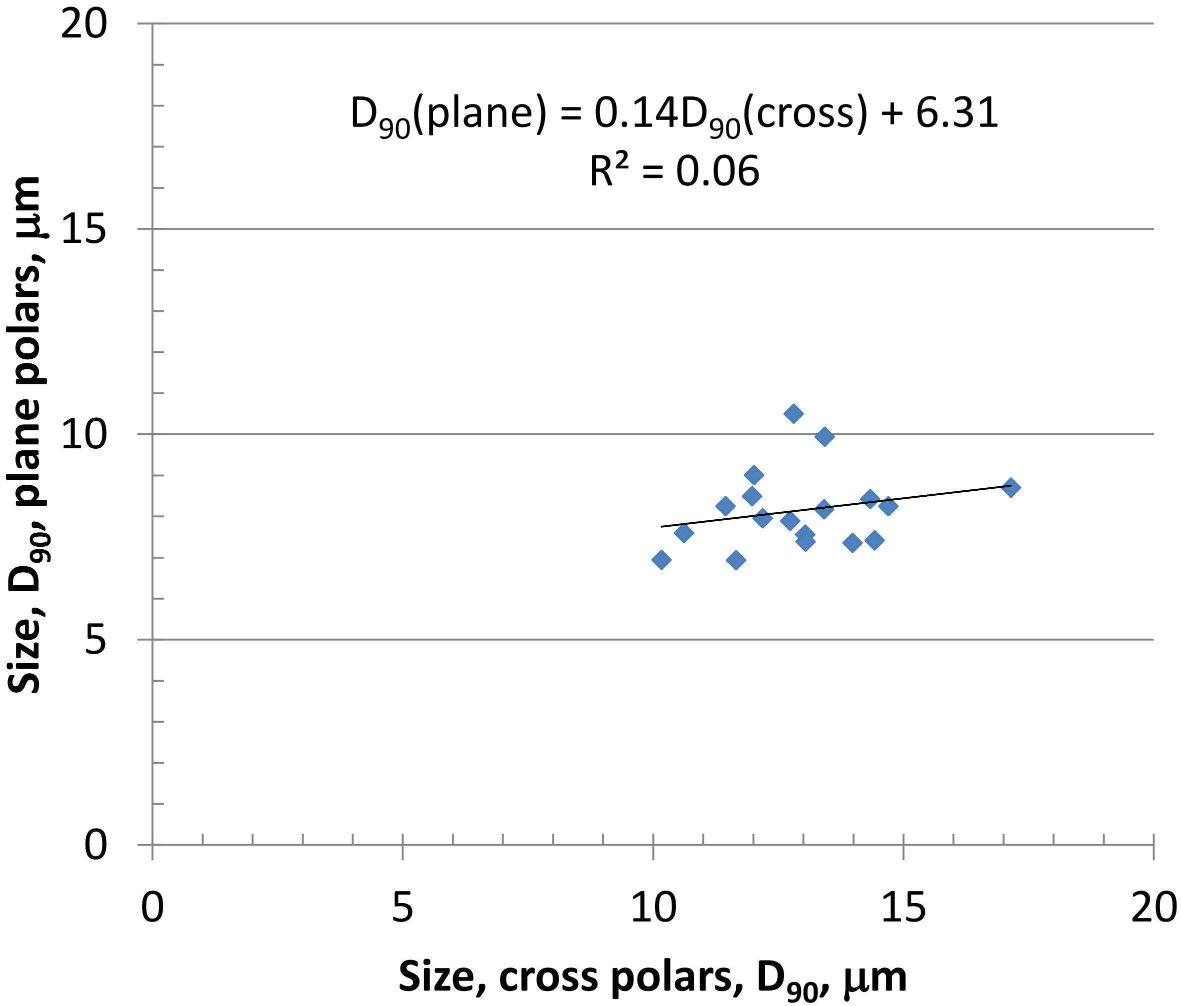


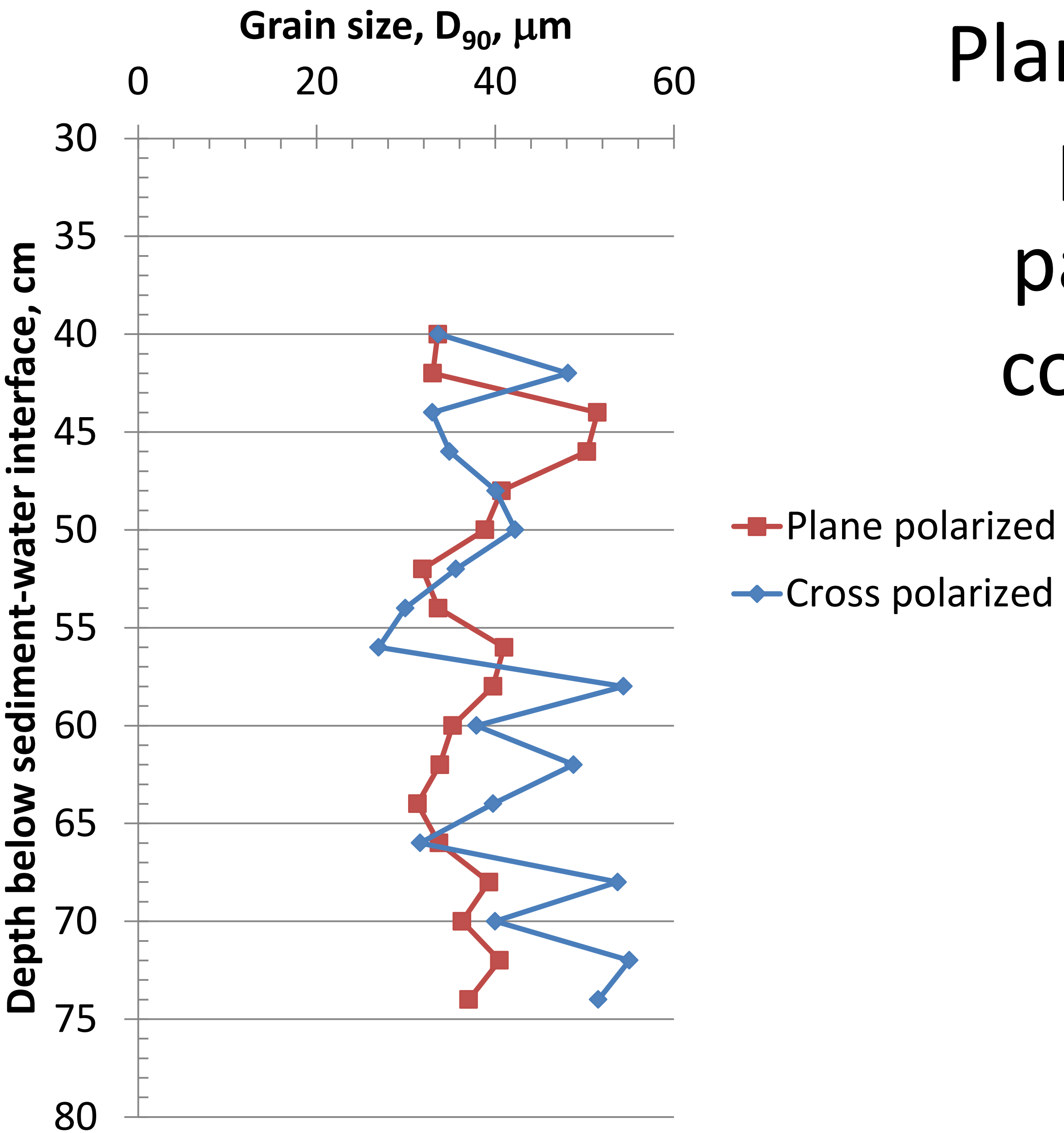
Results

File Edit Font Results

	Label	Area	Major	Minor	Angle	Circ.	Feret	FeretX	FeretY	FeretAngle	MinFeret	AR	Round	Solidity
505	Mean	56.12	7.49	4.42	74.27	0.80	8.37	558.53	448.22	100.80	5.11	1.67	0.66	0.85
506	SD	240.47	8.53	4.84	56.91	0.21	9.38	342.18	234.39	47.15	5.76	0.55	0.20	0.10
507	Min	0.56	0.85	0.74	0	0.14	1.06	1.50	2.25	8.13	0.75	1	0.23	0.52
508	Max	4917.45	99.75	62.77	180.00	1	105.87	1197.89	898.04	175.10	73.86	4.33	1.00	1

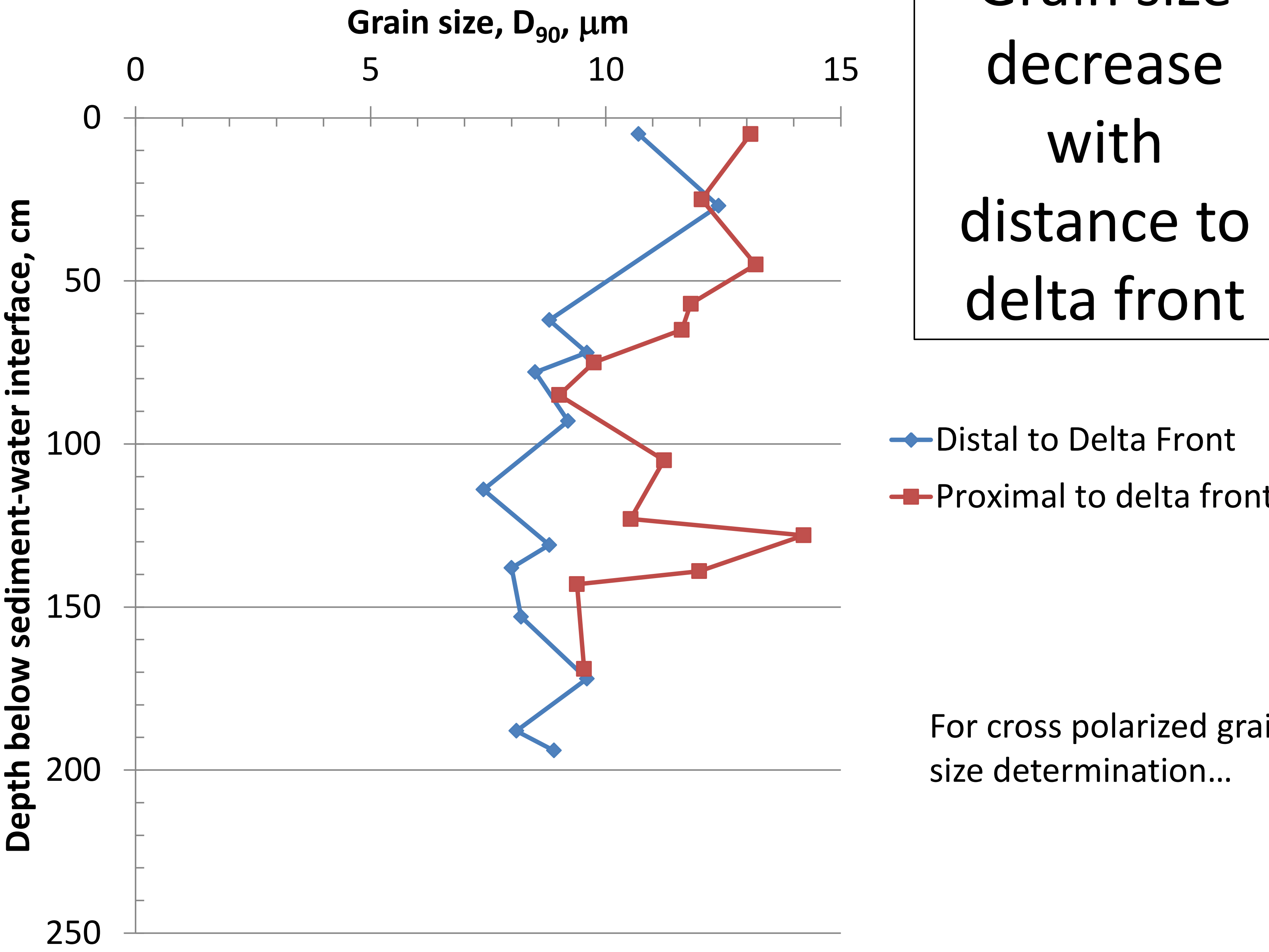
Plane and crossed polars measure different aspects of sediment cores





Plane and cross polarized particle size comparison:

Grain size decrease with distance to delta front



For cross polarized grain size determination…

In Summary

- There are clear layers in some reservoirs with large variations in grain size
- Larger particles on the delta could mean larger mud sizes in deeper water
- Mud particle size distributions appear to be power laws (coefficient ≈ 1.8, exponent ≈ -1.4)
- Filtering for opaques is possible
- **Mud** particle size decreases with distance from delta fronts

Questions?

Muddy Waters: particle size distributions in a Holocene lacustrine delta

ABSTRACT

We extracted three 1-2 m long sediment cores from the distal portion of a Holocene lacustrine delta in upstate New York (Otsego Lake, 42° 43' 10.81" N, 74° 55' 29.88" W), at distances of 40, 60, and 100 m from the gravel topset-foreset-bottomset transition, which was close to the subaerial-to-subaqueous boundary on the delta. Our intent was to document stratigraphy and identify features in the cores related to flood discharges. We hypothesized that grain size should vary directly with discharge, and thus, grain size variations could serve as a proxy flood record. Given the large number of reservoirs and lakes in central New York, the effort could open up a significant library of flood records for the Holocene.

We find two moderately extensive layers—an organic-rich muddy unit overlying a gastropod-carbonate rich mud layer. We analyzed sediment smears on glass slides under the microscope at 10 power magnification for particle size distributions. ImageJ, a freeware developed by National Institutes of Health, contains macros for particle detection and measurement and provided a systematic method for characterizing particles. We sampled sediment cores every 2 cm for grain size distributions. Because of significant and varying amounts of opaque and isotropic material in the slides, we conducted a test of particle detection under cross polarized light. Grain sizes vary from 1-100 micrometers on the slide smears. Distributions for plane and cross polarized light are substantially uncorrelated with each other. Plane polarized light microscopy reveal power law distributions of probability density functions for cumulative particle sizes (average coefficient and exponent in the power law are 1.6 and -1.4 respectively). Cross polarized light reveal particles dominated by quartz and calcite mineralogy, and yield a wider variation in distributions. For power law fits to the cumulative distributions in cross polarized light, average coefficient and exponent in the power law are 6.0 and -1.6 respectively. Size-depth diagrams show a decrease in particle size with distance from the delta front, consistent with a stream competence hypothesis. Particle size variation within a single core suggests several larger events have occurred over the time period required to accumulate 1.8 m of sediment.

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T111. Lake Systems Through Space and Time