Acoustic Measurements of Clays and Silts

Wayne Carpenter¹, Daniel Wren², Roger Kuhnle², James Chambers¹, and Jeff Diers²

¹ National Center for Physical Acoustics University of Mississippi, University, MS 38677

² National Sedimentation Lab USDA-ARS, Oxford, MS 38655

* Work supported by F.I.S.P.

National Center for Physical Acoustics



Research Objective

•Develop a technique for using a single acoustic frequency to measure fine particle concentration in water

–Compile a database of attenuation and backscatter data with the goal of using acoustic techniques to measure the concentration of fine sediment particles (0.1 - 64 micron diameter) in water.

–Attenuation and backscatter data will be analyzed and presented for known concentrations of bentonite (0.2 – 1 μ m), illite (0.2 – 2 μ m), kaolinite (2 – 5 μ m), and silt (45 – 60 μ m) as well as clay/silt mixtures.



National Center for Physical Acoustics



Calibration Tank

- Run known concentrations, particle sizes, and distances
- Obtain physical samples to measure concentration
- Measure acoustic backscatter/attenuation to develop empirical models

Receive

X1 Y1 Y2 X2 **Transmit** Transducer Transducer Pump **National Center for Physical Acoustics**

Cal. Tank (cont.)

Using 20 MHz immersion transducers, data were acquired by a computer equipped with a 1GS/s oscilloscope and a preamp.

• Input Signal: 20 Mhz, 300 V_{p-p} , 100 cycle, 10 ms wait between bursts, 1000 pings/data set (3 data sets total)





Summary of Attenuation Data



Close-up Detail of Low Concentration Data



Comparison between Clay/Silt Mixtures vs. Kaolinite Clay and Silt



Attenuation for Varied Clay/Silt Mixtures



Close-up Detail of Low Concentration Data (Revisited)



Backscatter and Attenuation for Bentonite (0.2 – 1 μm)



Backscatter and Attenuation for Kaolinite (0.2 – 2 μm)



Backscatter and Attenuation for Silt (45 – 60 μm)





Attenuation







Summary and Conclusions

- New attenuation and backscatter data were collected for a wide range of concentrations for clays, silts, and clay/silt mixtures
- Attenuation levels for mixtures fell between levels for individual constituents
- Backscatter levels were less responsive to particle size than expected
 - Likely due to flocculation, in spite of careful procedure
 - Must measure in-situ particle size
- Based on the data here, it is likely that the combination of backscatter and attenuation will allow for rough (clay vs. silt) particle size discrimination with 20 MHz signal



National Center for Physical Acoustics



Future Work

- In-situ effective particle-size measurements will be obtained for clays, silt, and clay/silt mixtures using LISST-100X from Sequoia Scientific.
- More rigorous measurements of the detection threshold and resolution of the measurements.
- Based on the results presented and those obtained in future experiments, a technique for using a single acoustic frequency to measure fine particle concentration in water will be developed.
- Construct a prototype instrument and install on a floating instrument platform in the ARS Goodwin Creek Experimental Watershed and use it to monitor fine sediment concentrations during storm events.



National Center for Physical Acoustics



Questions?

Thank you for your attention.



