

Characterization and Monitoring: Current Approaches and Challenges

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Subsurface Access

- ▶ Characterization, sampling, instrumentation
- ▶ Subsurface Drilling
 - Auger Drilling
 - Solid Stem Auger
 - Hollow Stem Auger
 - Rotary Drilling
 - Bucket Auger
 - Percussion (Cable Tool)
- ▶ Cone Penetrometer
- ▶ Outcrops
- ▶ Excavations



Sediment Characterization

► Observation

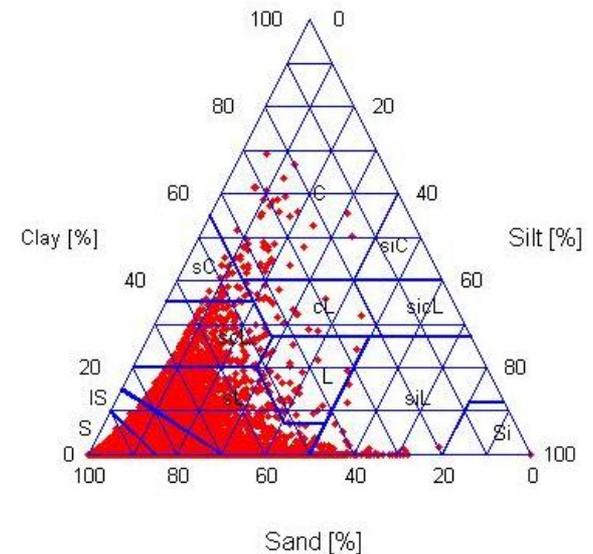
- Lithologic logs (driller, geologist)

► Physicochemical Properties

- Particle size distribution (50K)
- Water retention/field capacity (1.5K)
- Cation exchange capacity (1.5K)
- Surface area (0.5K)
- K_d (?)
- Mineralogy, XRD, XRF (0.5K)
- Electrical properties (0.5K)
- Gamma energy (0.5K)

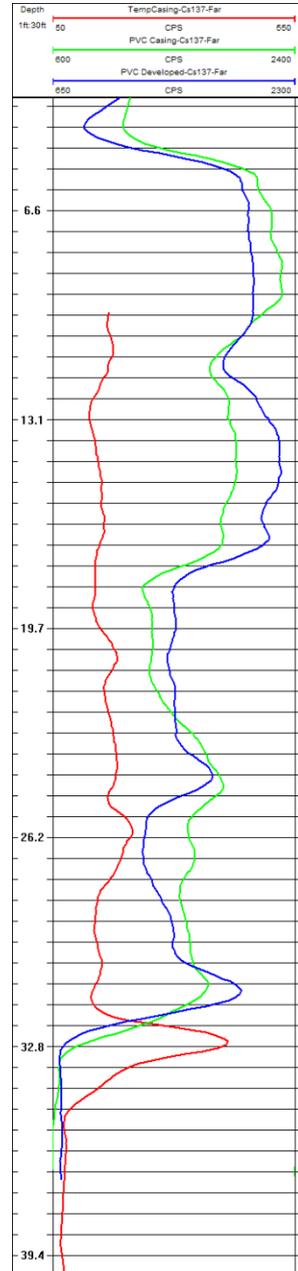
► Contaminant measurements

- Soil samples
- Pore water leaching/extraction
- Electrical (resistivity, ion specific)



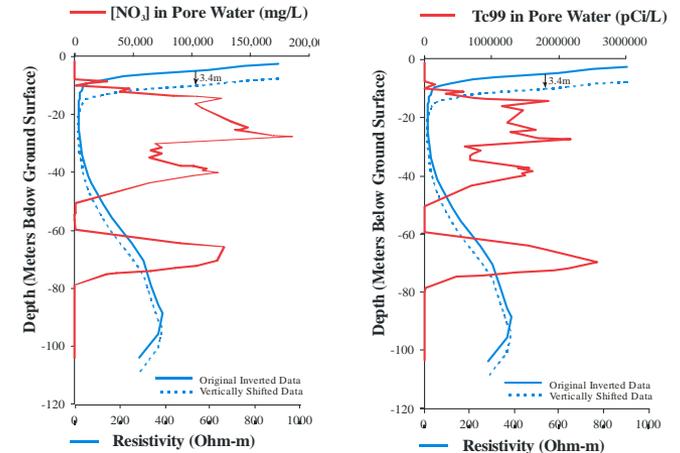
In Situ Characterization- Borehole Geophysics

- ▶ Over 8000 boreholes
 - Steel casing → nuclear tools
 - Pre-completion logs most useful
- ▶ Neutron scattering
 - Above water table
 - Calibration
- ▶ Spectral gamma
 - Total depth
 - Mostly qualitative use
- ▶ DOE-IFRC Logging system
 - Porosity, density, EC etc
- ▶ Cone penetrometer
 - Shallow refusal depth

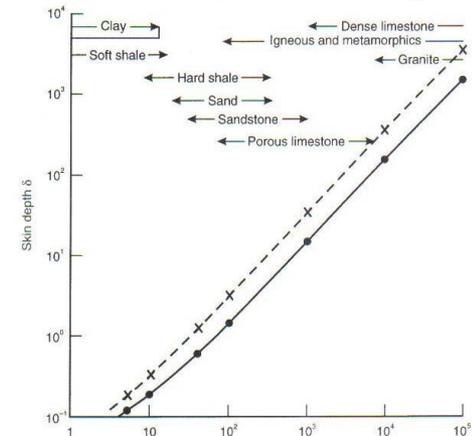


In Situ Characterization- Surface Geophysics

- ▶ Large, complex, electrically conductive plumes
- ▶ Electrical and electromagnetic
 - Resistivity
 - Lithology (Clay content)
 - Moisture content
 - Pore fluid conductivity
 - Infrastructure (tank farms)
 - GPR, TDR, capacitance, NMR
 - limited by high salt
- ▶ Seismic
 - Reflection
 - Refraction
- ▶ VZ Hydrology/Soil physics
 - Permeability, water retention, thermal, electrical



Vertical profiles of porewater chemistry and 2D ERT inversions for borehole C5923.



Variation of skin depth δ as function of resistivity in ohm-m for $\epsilon_r = 8$ (crosses) and $\epsilon_r = 40$ (circles)

Characterization Challenges

▶ Subsurface Access

- Sample integrity
- Well completions
- Instrumentation

▶ Sediment Characterization

- Mostly dry-sieve
- Property Transfer Models- mostly from < 2 mm sediments
- Petrophysical relationships- non-unique

▶ Model Parameterization

- Initial conditions- extrapolate data from sparse boreholes to 3-D domains
- Inverse modeling- large parameter-dimension, correlated parameters
- Translation of physicochemical and geophysical information into model input parameters (flow, transport, reactivity)



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Vadose Zone Monitoring

- ▶ Fluid Saturation
 - Nuclear methods (NP, Gamma)
 - Electrical/EM methods (ERT, TDR, GPR)
- ▶ Capillary pressure (matric potential)
 - Tensiometers/Heat dissipation
 - Resistance blocks
 - Thermocouple psychrometers
- ▶ Temperature
 - Thermistors, thermocouples
- ▶ Fluid transmission capability
 - Borehole permeameters (water, air)
 - Flux meters
 - Capillary pressure
- ▶ Pore-fluid composition
 - Soil/water sampling analysis
 - Cone penetrometer
 - Geophysics (time lapse)



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Vadose Zone Monitoring Challenges

▶ Fluid Saturation

- NP- limited to above water table
- Perched water complicates lithologic interpretation
- Electrical/EM- impacted by salinity and saturation

▶ Capillary Pressure (matric potential)

- Installation, operation, maintenance
- Calibration

▶ Temperature

- Installation, maintenance

▶ Fluid transmission capability

- Uncased hole

▶ Pore-fluid composition

- Discrete undisturbed samples
- Pore water extraction
- Waste disposal costs
- Geophysics- non-unique responses



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Backup Slides

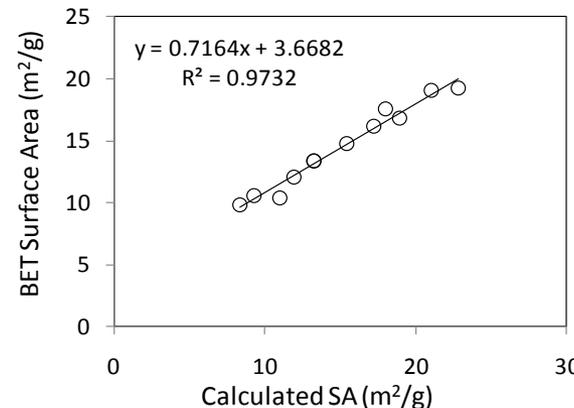
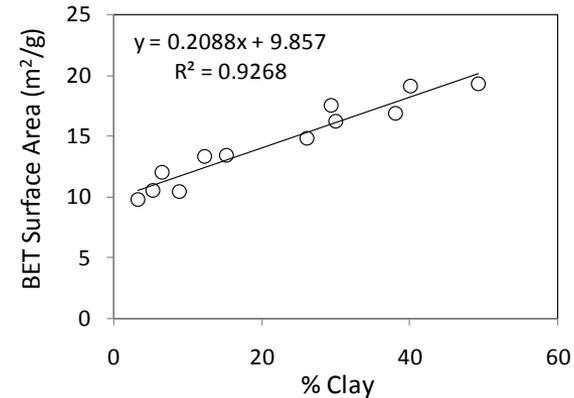
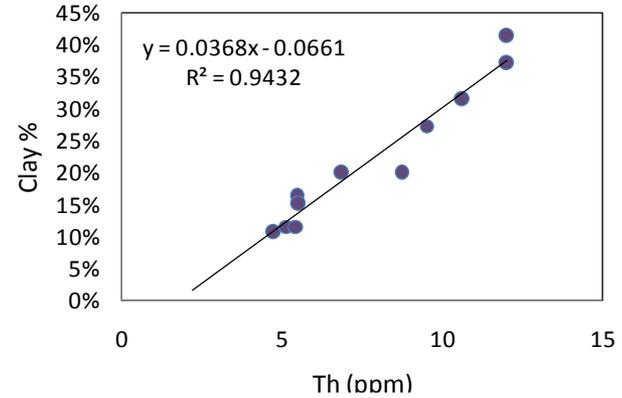


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Application- Sediment Characterization

- ▶ Separate sediments into size fractions
 - Create model mixtures
- ▶ Characterize whole sediments and fractions
 - Particle size distribution
 - Shape indices
 - Packing efficiencies
 - Porosity
 - Permeability
 - Water Retention
 - Specific Surface Area
 - Cation Exchange Capacity
 - Natural Isotope Abundance
 - Surface conductivity



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