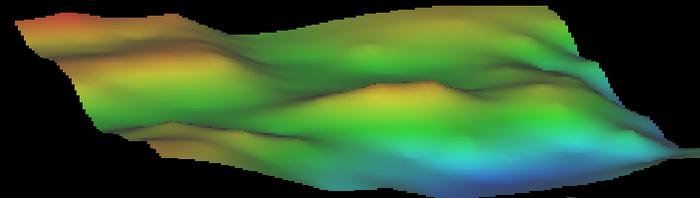
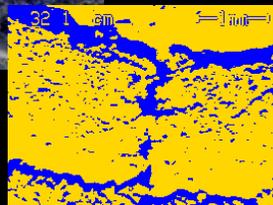
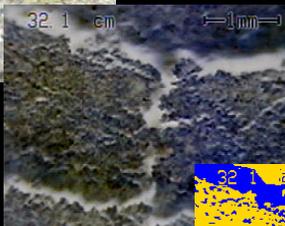
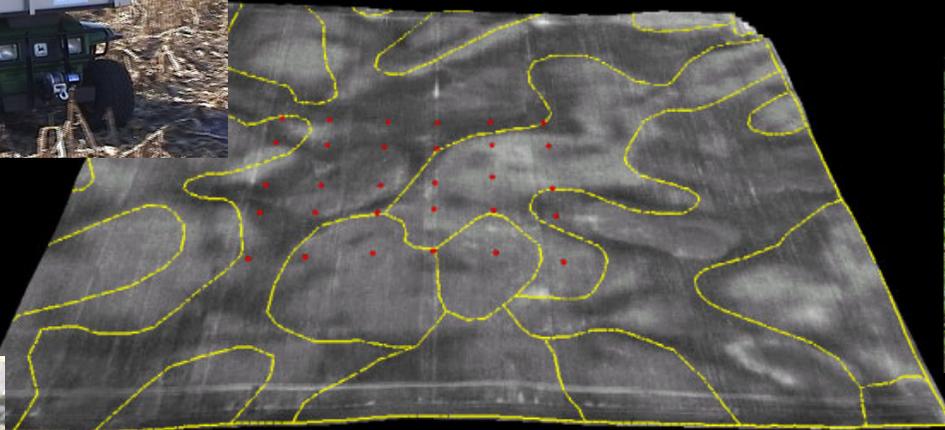
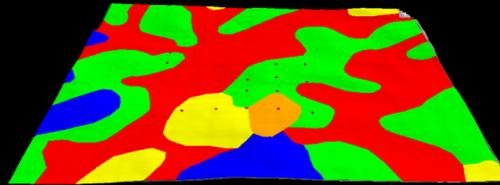


# Soil Information System

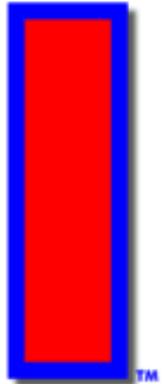


Dan Rooney

25 June, 2002

Earth Information Technologies, Corp.

[www.EarthIT.com](http://www.EarthIT.com)



**Earth  
Information  
Technologies  
Corporation™**

**“Putting Information  
in its Place”**

- **Resource Mapping Technologies**
- **Location Based Services**
- **Mobile Web-Based Mapping**

# **Soil and Topography Information**

- **Agriculture**
- **Archaeology & Forensics**
- **Construction**
- **Environmental Site Assessments**
- **Forestry**
- **Road Building**
- **Turf**
- **Utility Placement**
- **Watersheds**
- **Wetlands**

# How is Soil Information Obtained Today?

- **Soil information is collected from core sampling, pit excavation, non-invasive tools (Veris/EM38), and satellite/airborne imagery.**
- **Sometimes combined with yield, weather, and site management information.**
- **Process involves several disconnected and often unnecessary (overkill or underkill) steps.**

# Soil Sampling Errors

- **Sample placement**
- **Depth of Analysis**
- **Sample Manipulation**
- **Exposure**
- **Time**
- **Laboratory Analysis**
- **Documentation**
- **Interpretive**
- **Others**

# Soil Information System

- **Use BEST AVAILABLE TECHNOLOGY**
- **Drive field boundary/features of interest and obtain Soil Survey, DEM, imagery, yield data etc.**
- **Create high resolution DEM and perform EM/GPR survey**
- **Combine new data with existing data to select locations for point observations**
- **Make point observations to create high resolution 3-D, digital, soil and topography map**

# Soil Sensors used in SIS

- **Soil Imaging Penetrometer (SIP)**
- **Physical Property Penetrometer (PPP)**
- **Soil Moisture, Temperature, Resistivity Penetrometer**
- **Soil Color Penetrometer**
- **EM/GPR**
- **Other**

# Soil and Topography Information Obtained

## Soil

- **Compaction**
- **Texture**
- **Color**
- **Electrical Conductivity**
- **Moisture**
- **Temperature**
- **Organic Matter**
- **Structure**

## Topography

- **Elevation**
- **Slope**
- **Landscape Position**
- **Aspect**

# Information Zones

## Soil

- Impermeable layer depth
- Water holding capacity
- Plant available water
- Organic matter content
- Nutrient holding capacity
- Hydraulic conductivity
- Thermal

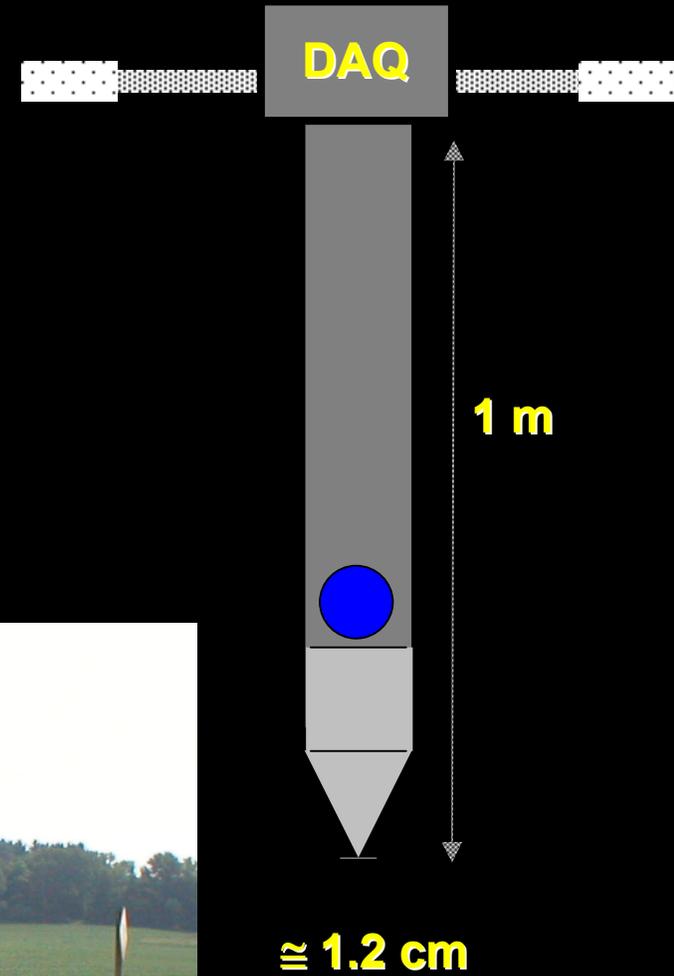
## Topography

- Length of Slope
- Depressions
- Watershed position
- Viewshed
- Proximity to other info.

# Other Sensors

- **pH**
- **Oxidation/Reduction Potential**
- **UV Induced Hydrocarbon**
- **LASER Induced Fluorescence (LIF)**
- **Cation Exchange Capacity**
- **others**

# Field Test Platforms



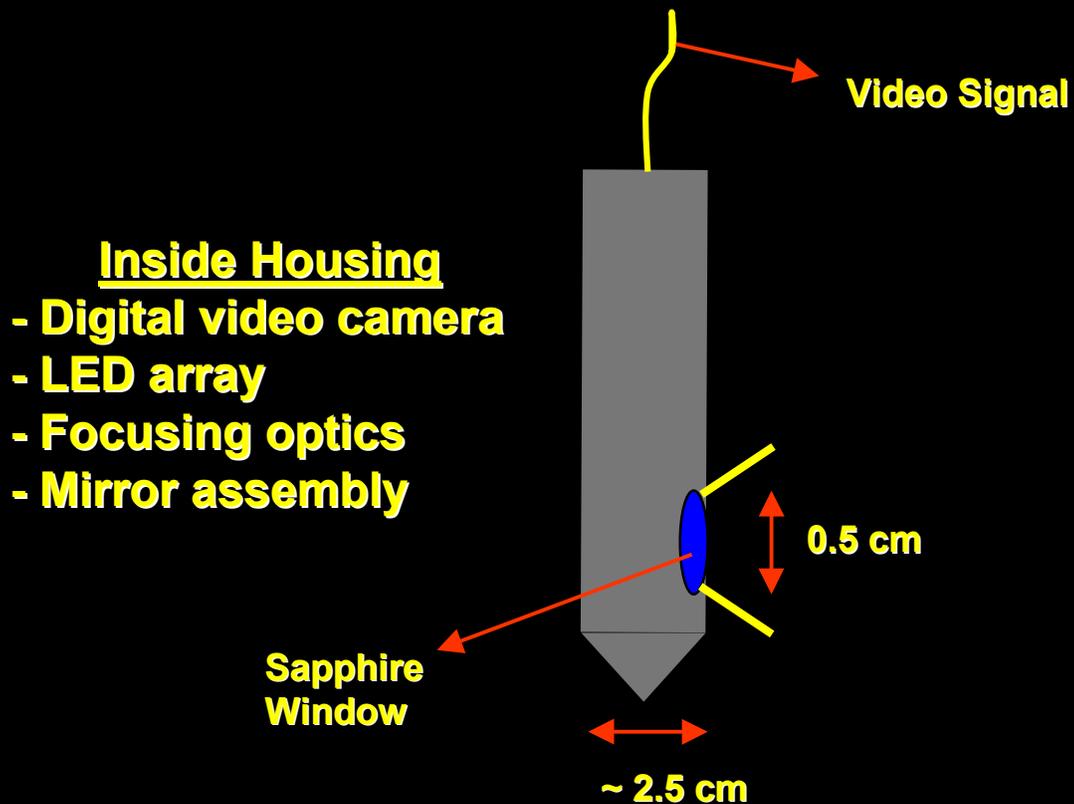
# Soil Survey

## Typical Horizon Description

**9 to 19 inches, dark brown (10YR 4/3) coarse sandy loam, dark brown (10 YR 3/3) moist; weak, fine and medium, granular structure; slightly hard, very friable, nonsticky, nonplastic; few, very fine and fine roots; common very fine and fine tubular pores; slightly acid (pH 6.5); numerous krotovinas and animal burrows; clear, wavy boundary.**

# Soil Imaging Penetrometer

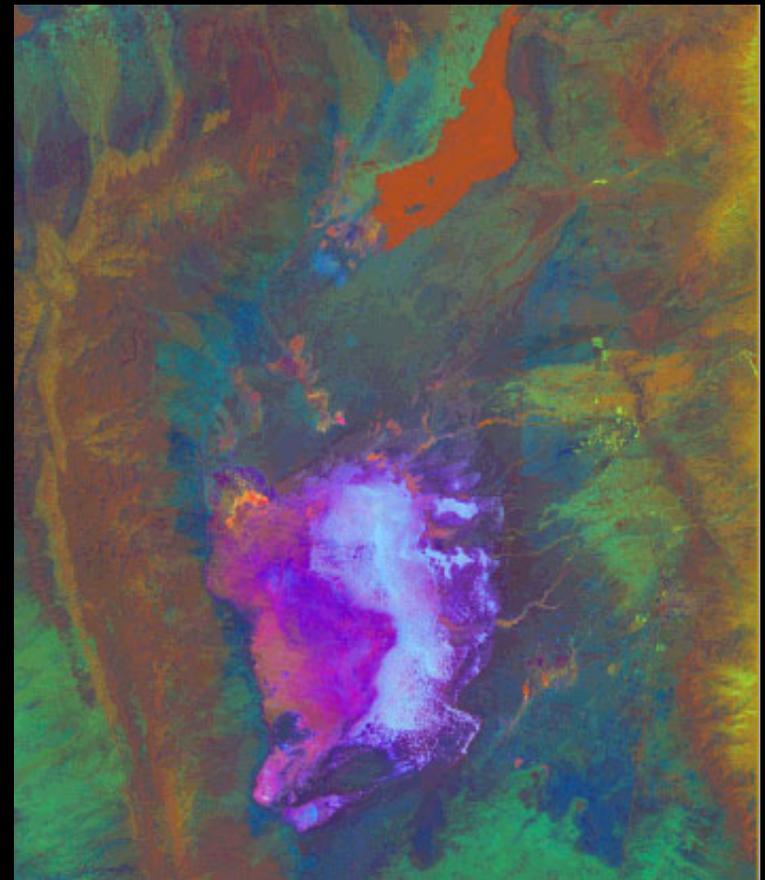
## "Subsurface Remote Sensing"



### Imagery Collected with...

- Depth
- Landscape position
- Other sensor data

### White Sands, NM



# Soil Imaging Penetrometer

## “Subsurface Remote Sensing”

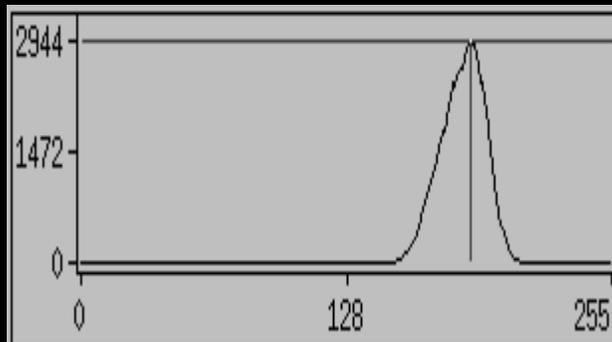




# Munsell Image Classes

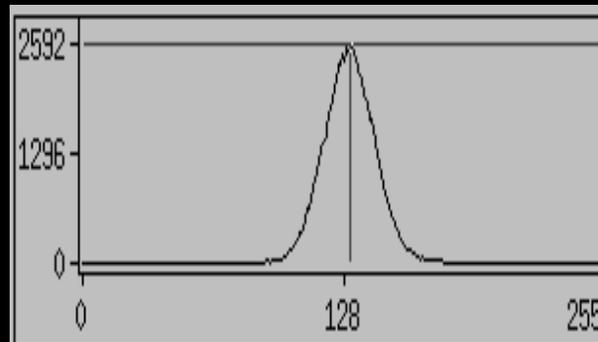


**10YR5/4**



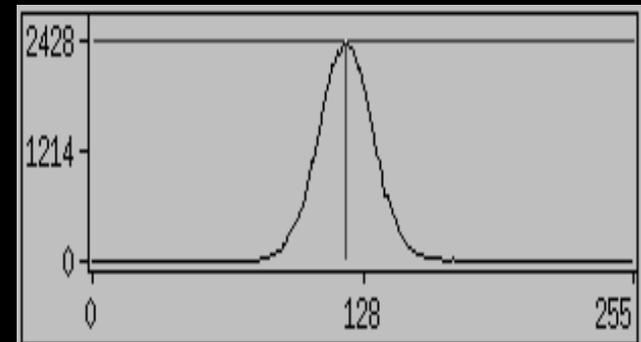
Raster: RED 8-bit unsigned  
Minimum: 100 Maximum: 225  
Mean: 183.119596 Std Dev: 10.949741  
Median: 184 Mode: 187 Most: 2944  
Cell Count: 76800 Bin Interval: 1

**Red (183)**



Raster: GREEN 8-bit unsigned  
Minimum: 50 Maximum: 228  
Mean: 130.474128 Std Dev: 13.451393  
Median: 130 Mode: 132 Most: 2592  
Cell Count: 76800 Bin Interval: 1

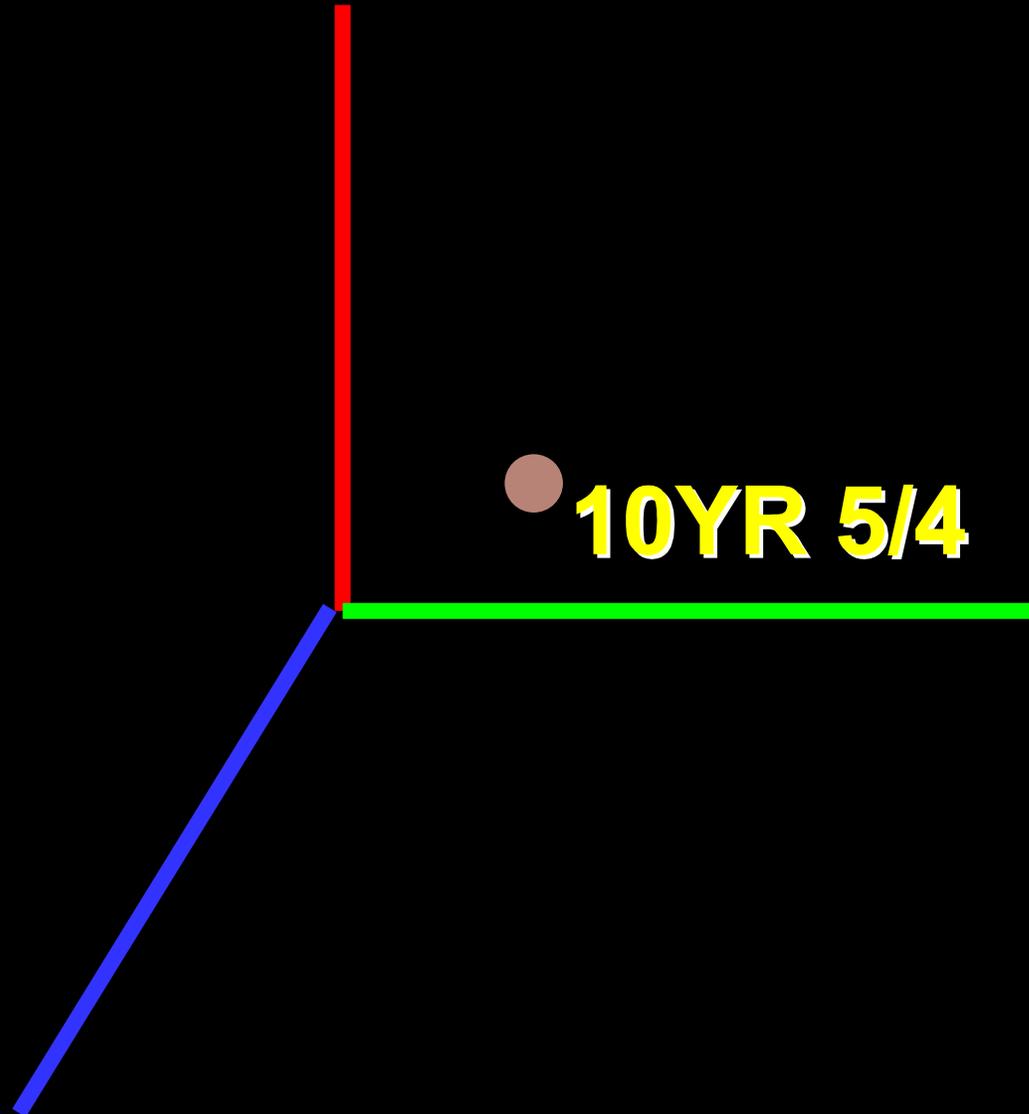
**Green (130)**



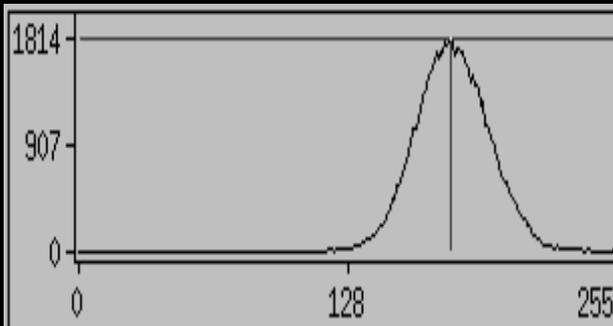
Raster: BLUE 8-bit unsigned  
Minimum: 36 Maximum: 222  
Mean: 119.523607 Std Dev: 13.756420  
Median: 119 Mode: 119 Most: 2429  
Cell Count: 76800 Bin Interval: 1

**Blue (119)**

# Minimum Distance to Mean (MDM)

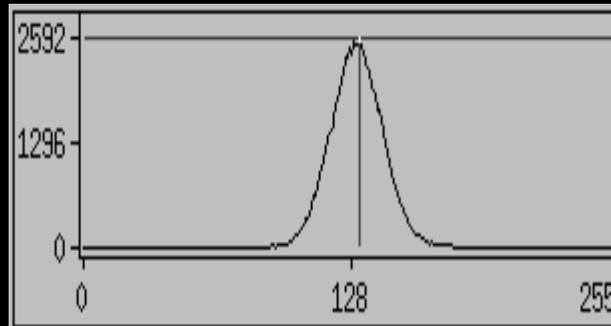


# Process Soil Image



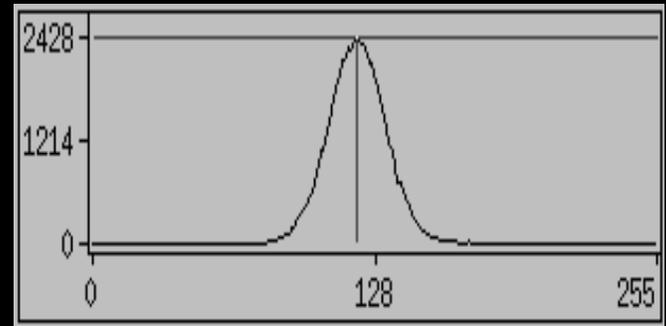
Raster: RED 8-bit unsigned  
Minimum: 86 Maximum: 255  
Mean: 177.682630 Std Dev: 18.181829  
Median: 177 Mode: 177 Most: 1814  
Cell Count: 76800 Bin Interval: 1

**Red (178)**



Raster: GREEN 8-bit unsigned  
Minimum: 50 Maximum: 228  
Mean: 130.474128 Std Dev: 13.451393  
Median: 130 Mode: 132 Most: 2592  
Cell Count: 76800 Bin Interval: 1

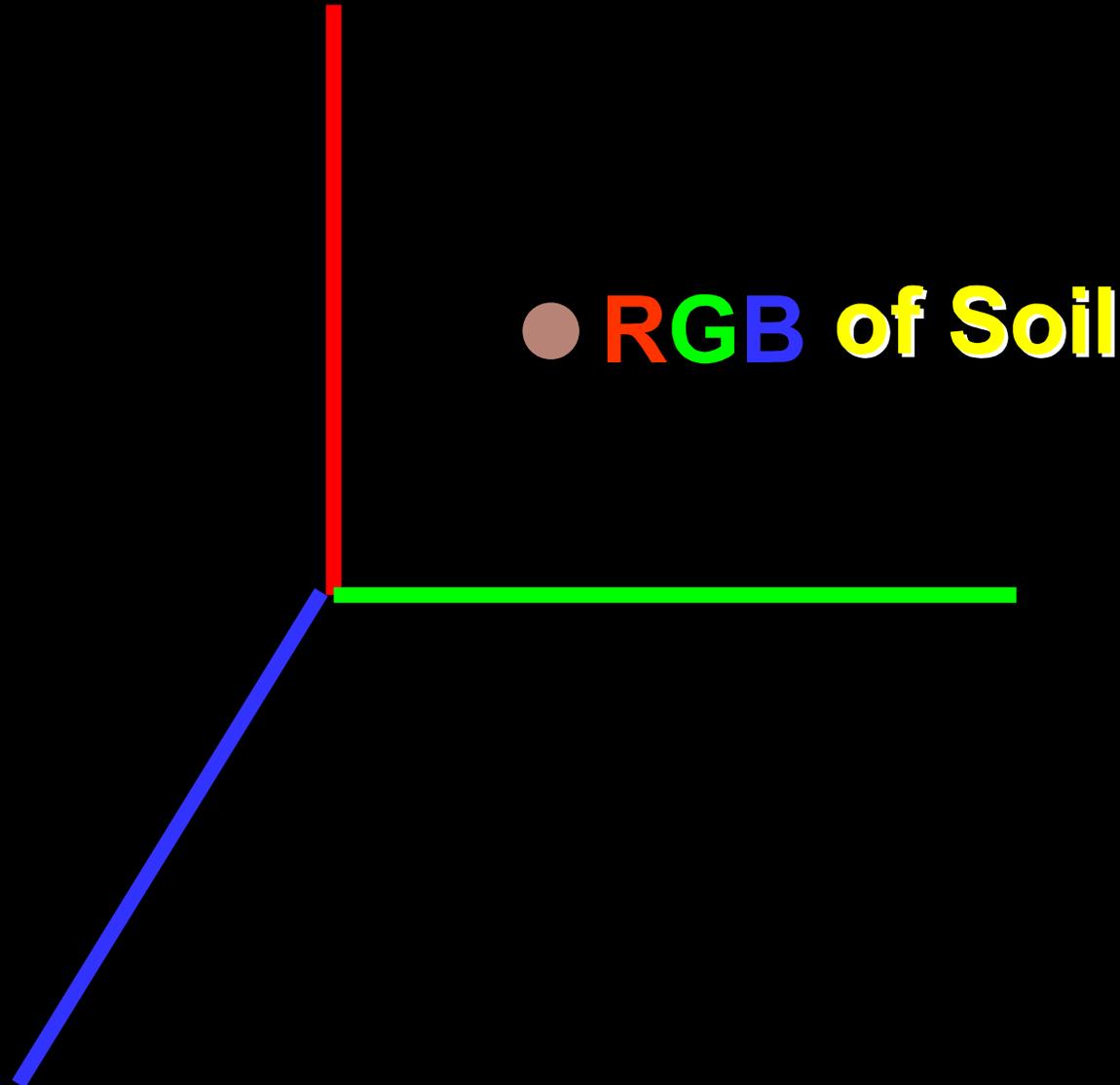
**Green (130)**



Raster: BLUE 8-bit unsigned  
Minimum: 36 Maximum: 222  
Mean: 119.523607 Std Dev: 13.756420  
Median: 119 Mode: 119 Most: 2429  
Cell Count: 76800 Bin Interval: 1

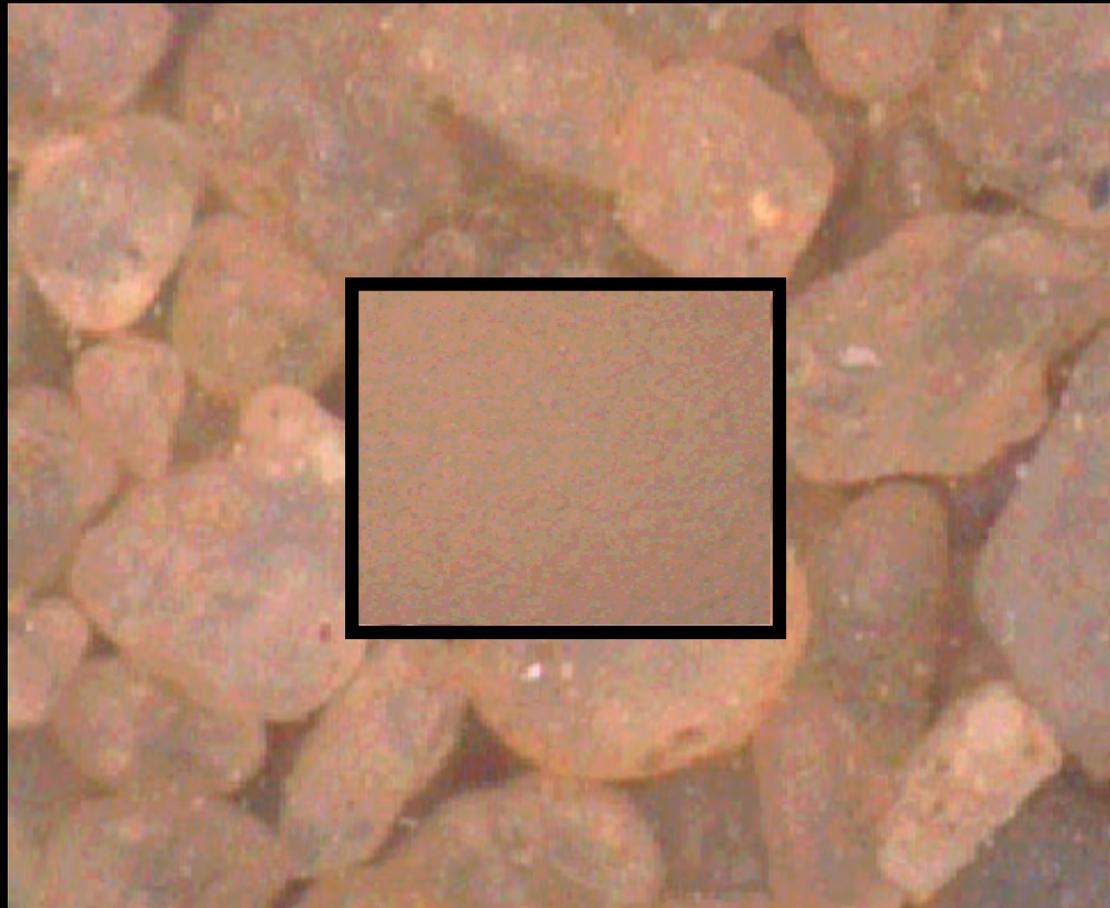
**Blue (120)**

# Red, Green, Blue (RGB) Color System

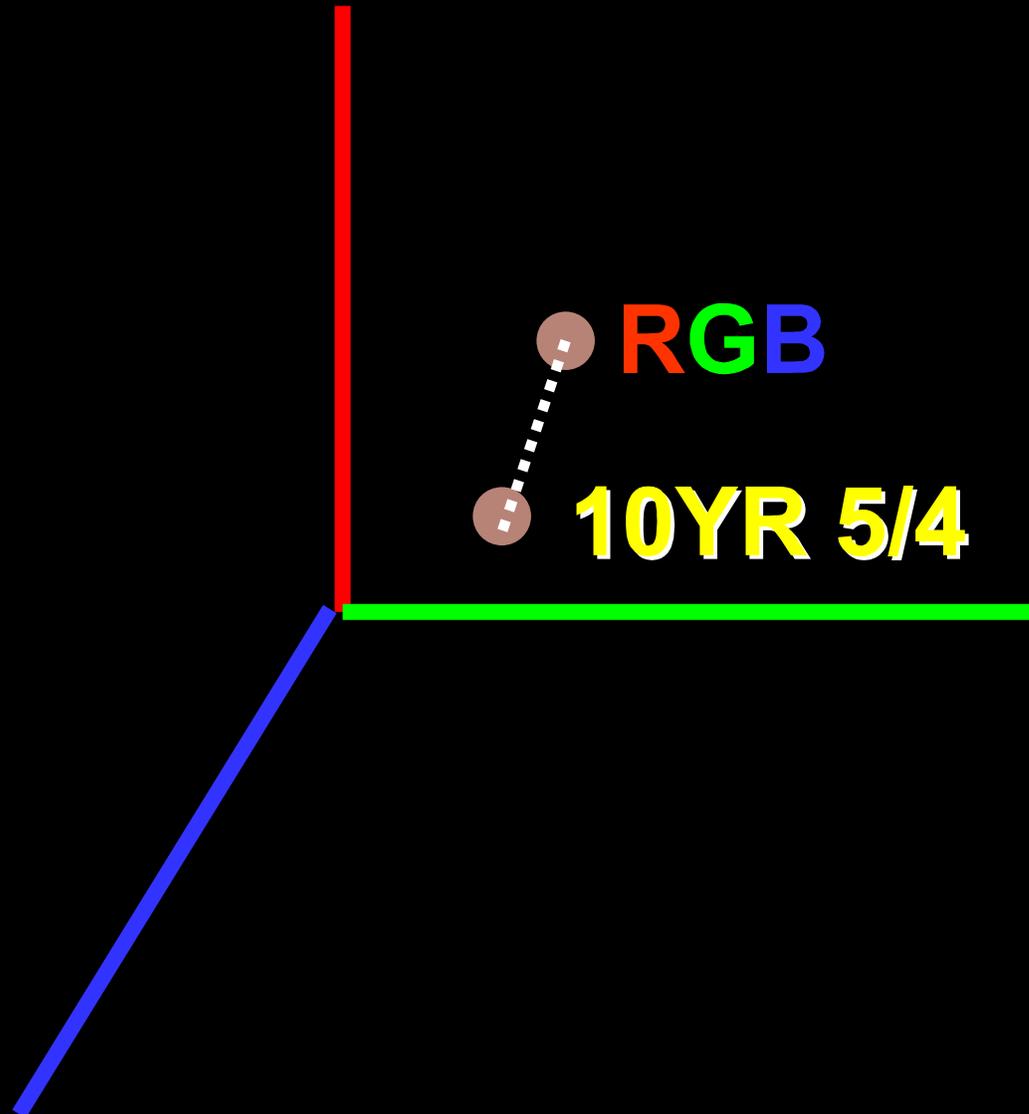


# Classification

**10YR5/4**



# Minimum Distance to Mean (MDM)





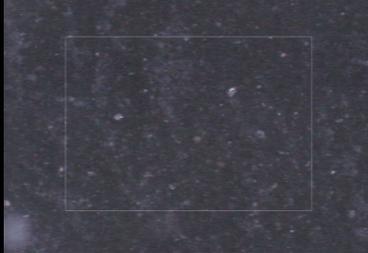
# Boundary Images

**Color**

**Structure**

**Texture**

**40 cm**



**90 cm**



**120 cm**



**45 cm**



**95 cm**



**125 cm**



**50 cm**



**100 cm**



**130 cm**



**55 cm**



**105 cm**



**135 cm**



**60 cm**



**110 cm**



**140 cm**



# Real-Time and *In Situ*

V15-105cm



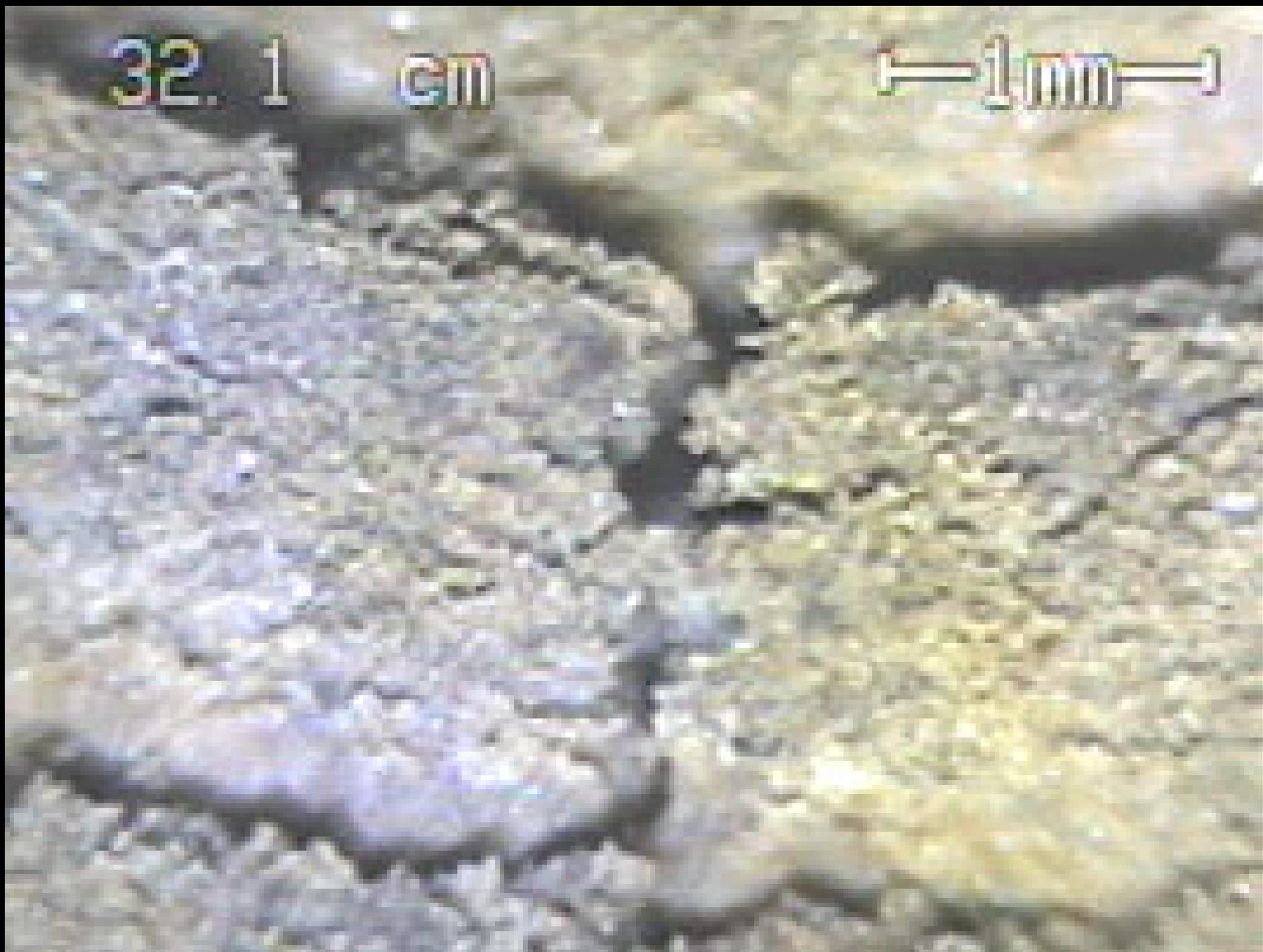
1.2 mm



# Real-Time and *In Situ*

32.1 cm

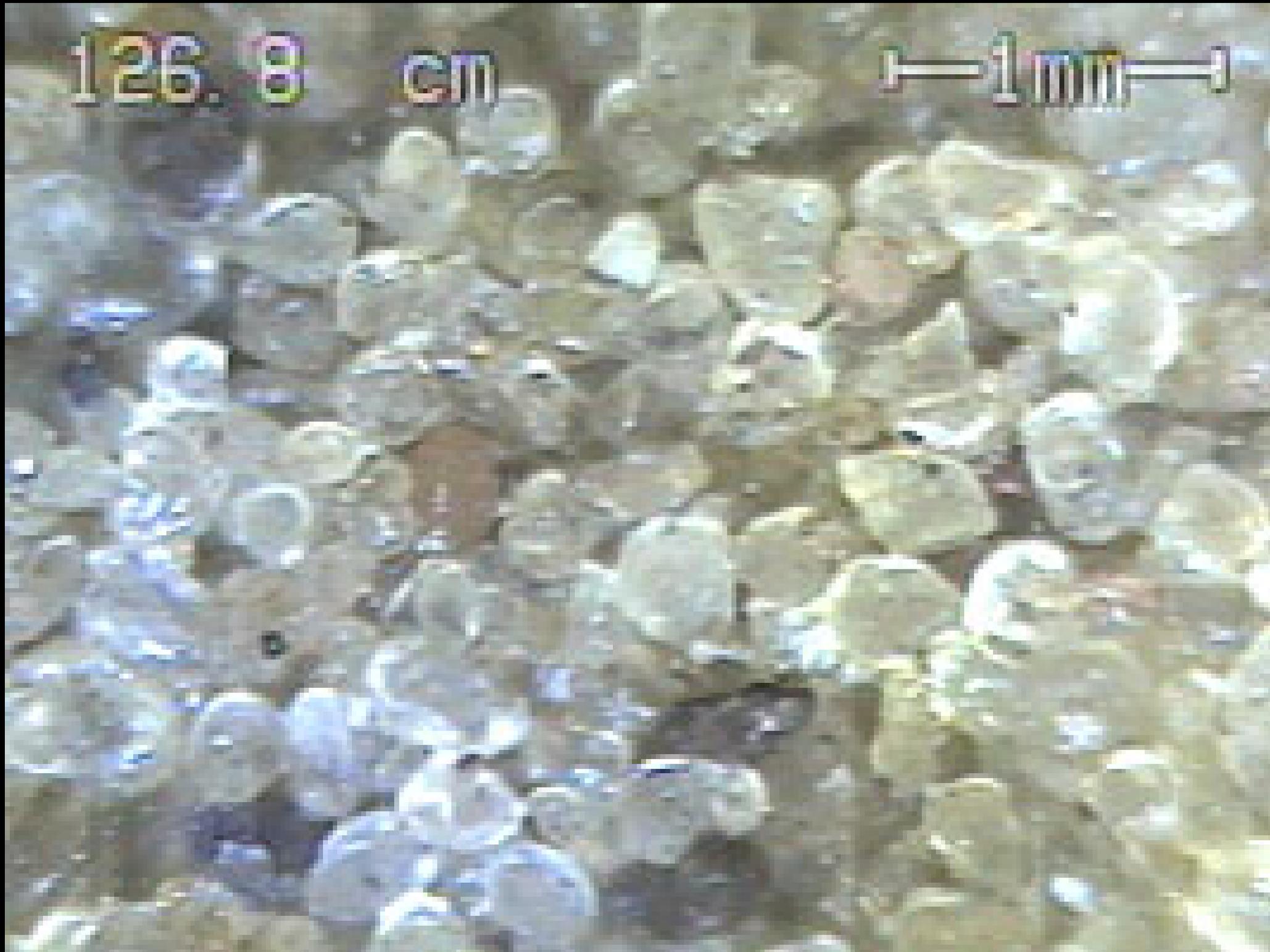
1 mm



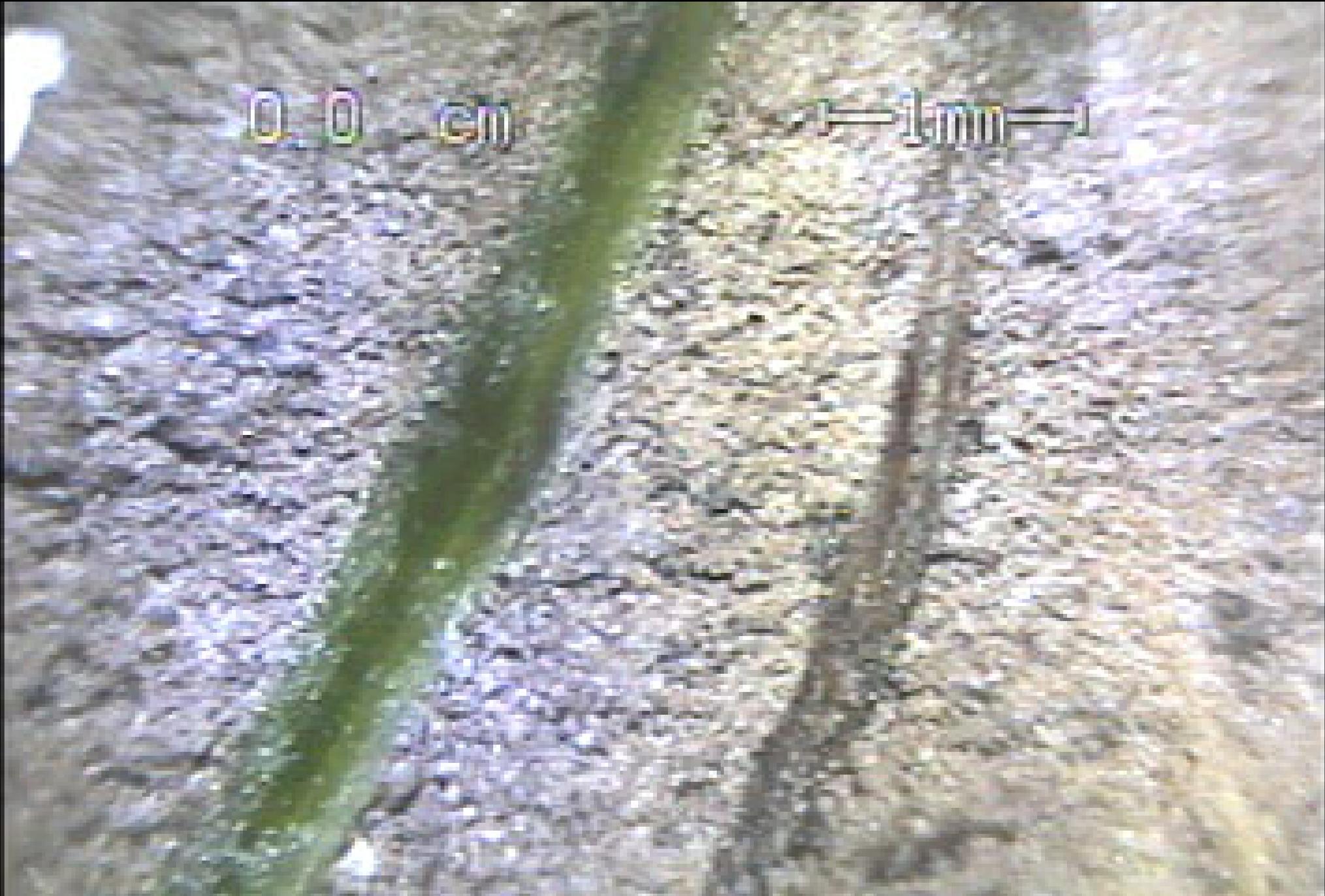
# Real-Time and *In Situ*

126.9 cm

1mm



# Real-Time and *In Situ*



# Real-Time and *In Situ*

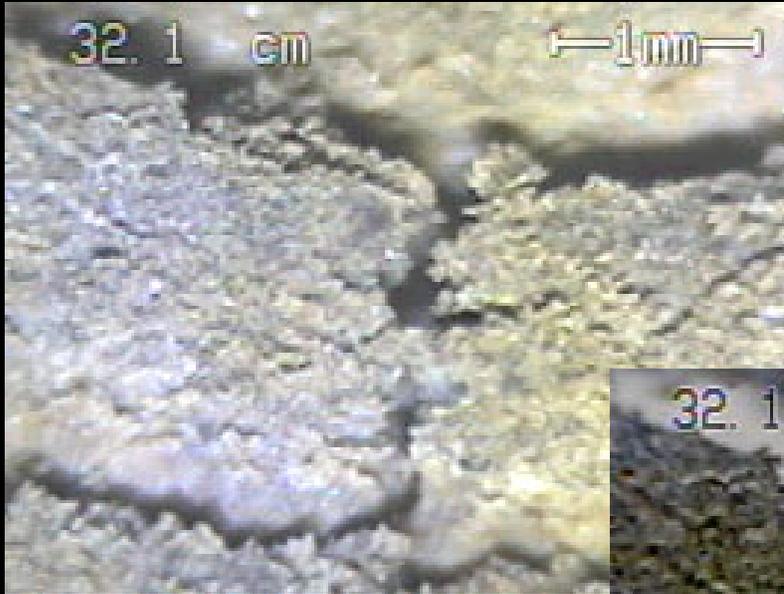
82.4 cm

1 mm



# Soil Image Processing

## Structure

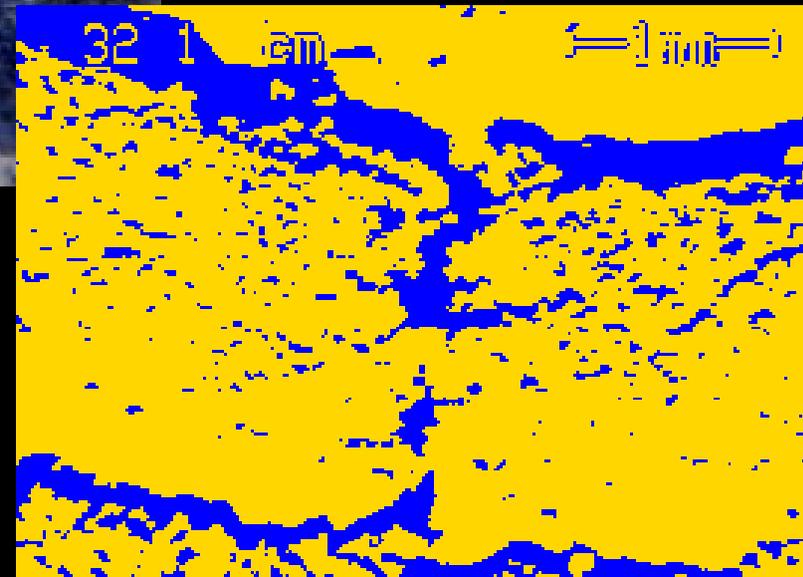


**Real-time in situ imagery from the Soil Imaging Penetrometer**



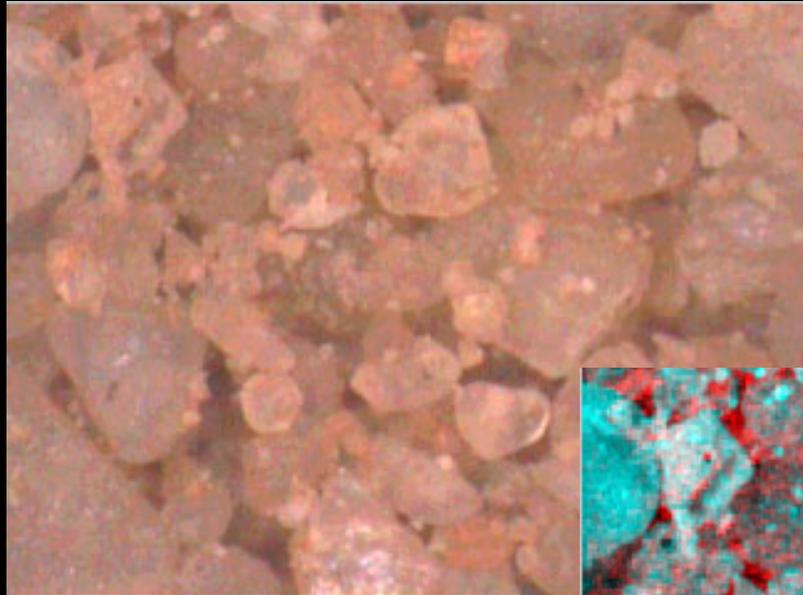
**...enhanced image showing soil structure**

**...image processing can be used to quantify soil characteristics**

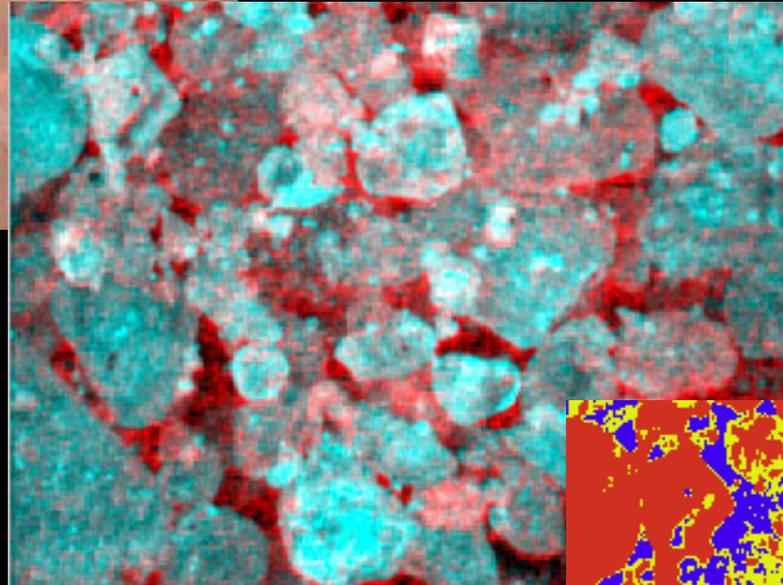


# Soil Image Processing

Porosity



Original

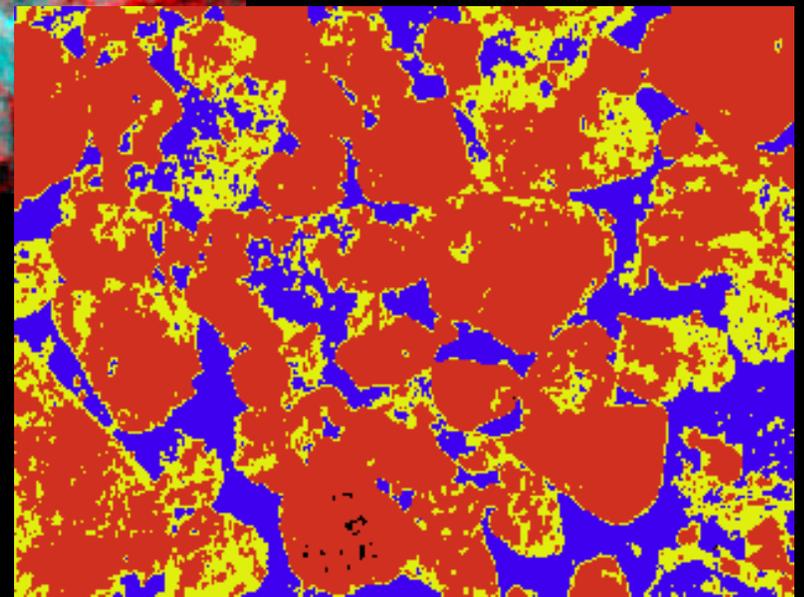


Principle  
Component  
Transformation

Scatter  
Plot



Cluster Analysis based  
on Transformation

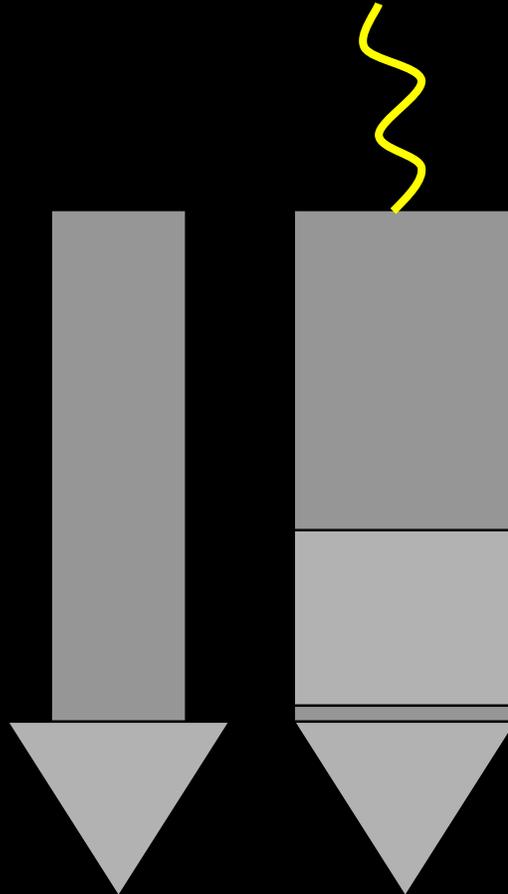


# Penetrometer Technology

## Two Standards in the United States

### ASAE\*

- 30° Tip angle
- 3 cm/sec
- Tip force only
- root emulation



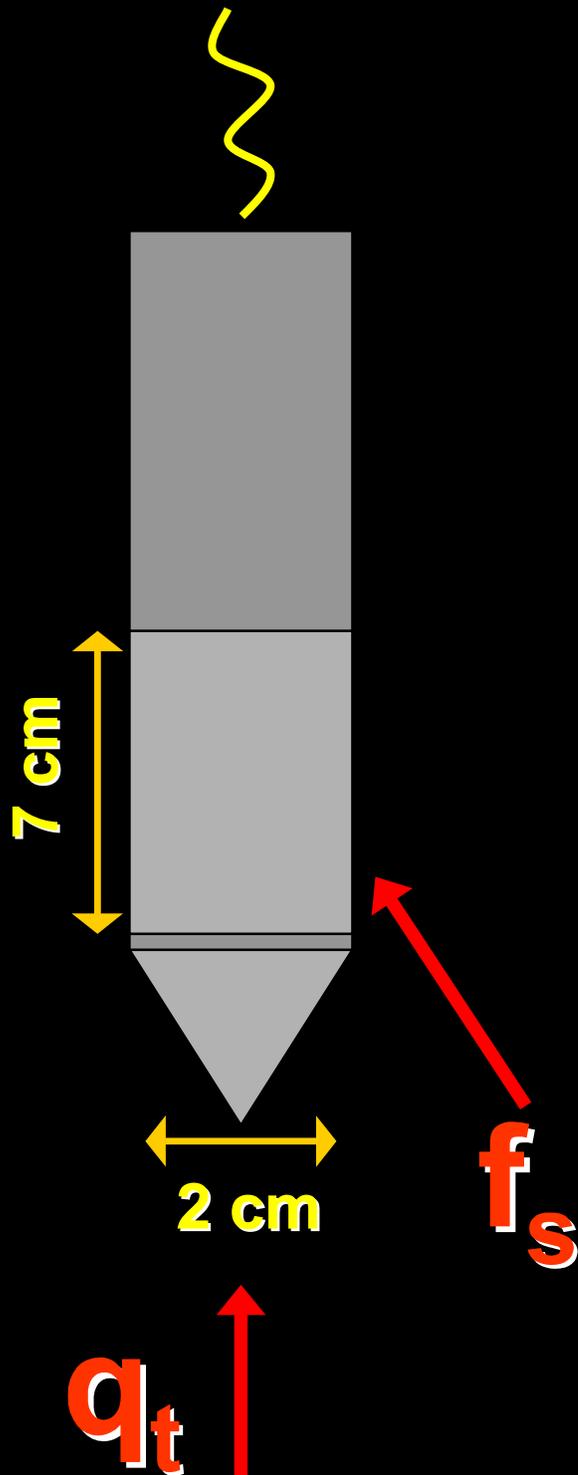
### ASTM\*\*

- 60° Tip angle
- 2 cm/sec
- Tip force
- Sleeve friction
- Physical properties

\* American Society of Agricultural Engineers

\*\* American Society of Testing and Materials

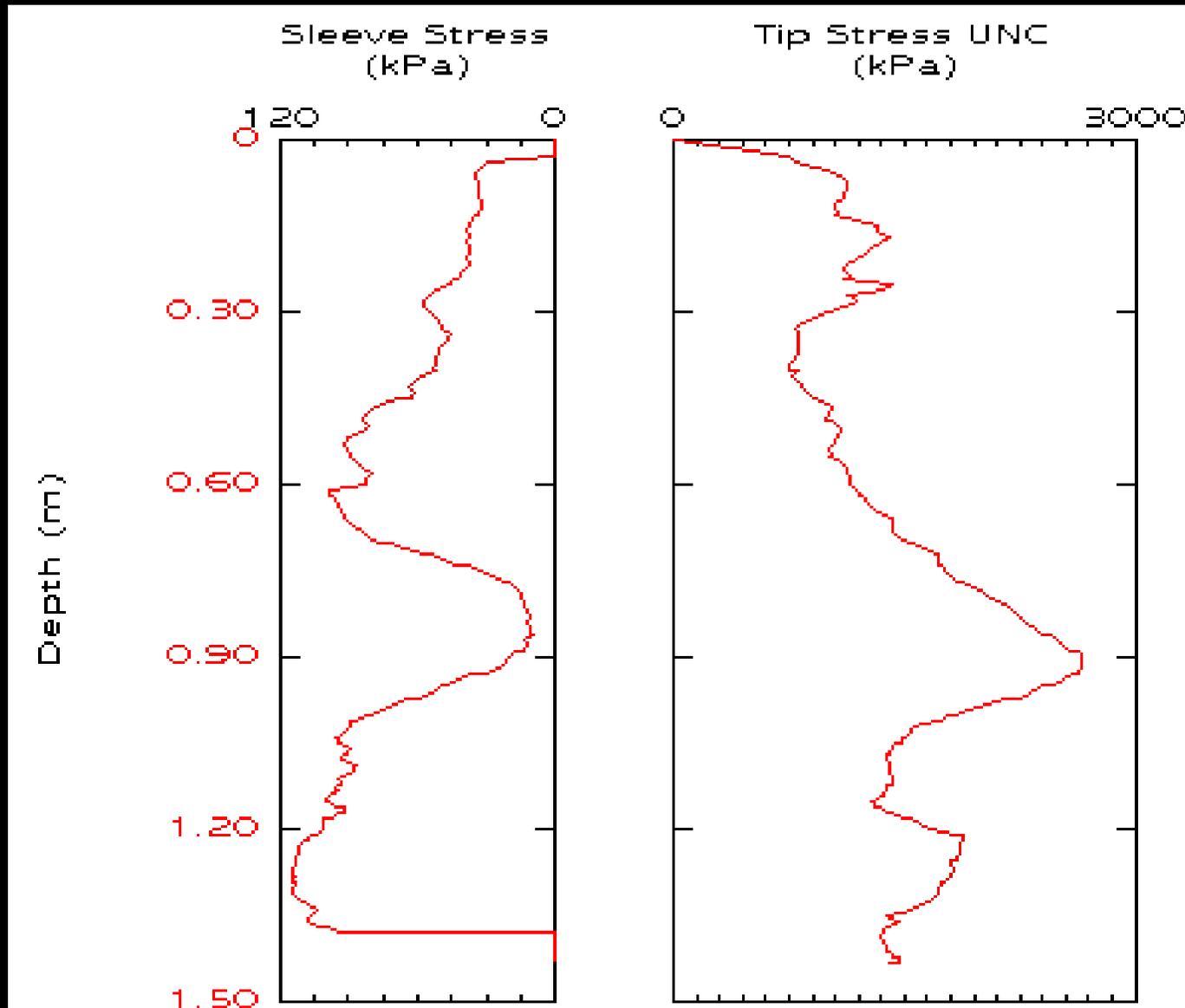
# Physical Property Penetrometer



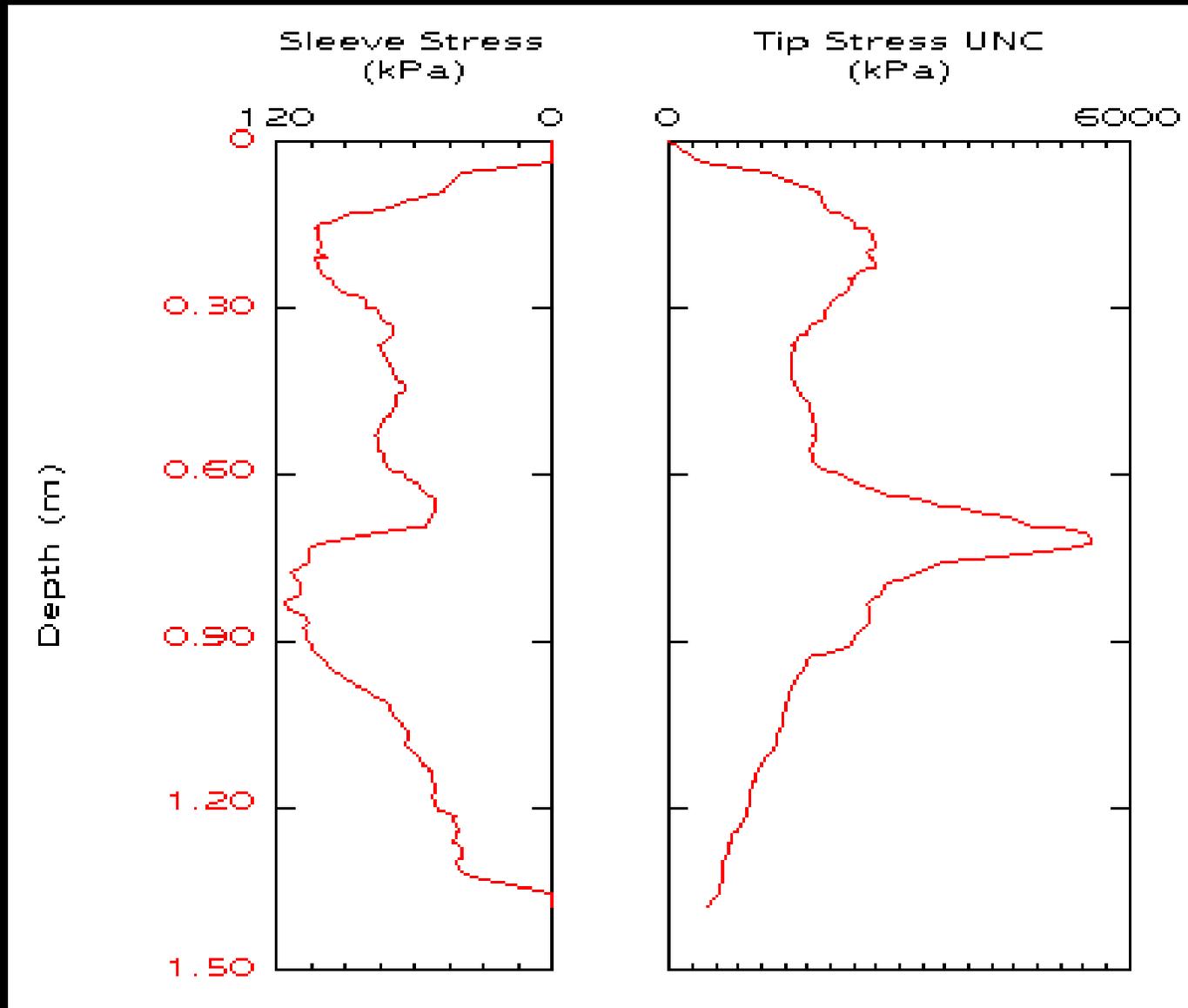
Generally...

- $q_t$  (Tip Force) increases with an increasing density
- $f_s$  (Sleeve Friction) increases with increasing cohesion

# Coarse Texture Classification



# Fine Texture Classification



# **Why is Knowing Soil Texture Important?**

- **Water Holding Capacity**
- **Plant Available Water**
- **Hydraulic Conductivity**
- **Surface Area of Particles**
- **Buffering Capacity**
- **Compactibility**

# **Water Holding Capacity of Soil Textures**

## **Water Content at Field Capacity**

**% by Volume (-0.3 bar)**

**Sandy Loam = 12%**

**Silt Loam = 30%**

**Clay = 35%**

# Plant Available Water of Soil Textures

## At Field Capacity

% by Volume (-0.3 bar)

**Sand = 7%**

**Silt = 21%**

**Clay = 16%**

# Hydraulic Conductivity of Soil Textures

**Sand =  $10^{-3}$  cm/s**

**Silt =  $10^{-5}$  cm/s**

**Clay =  $10^{-7}$  cm/s**

# Specific Surface Area of Soil Textures

In 1 gram of Soil

**Sand = 0.05 m<sup>2</sup>**

**Silt = 1.11 m<sup>2</sup>**

**Clay = 740 m<sup>2</sup>**

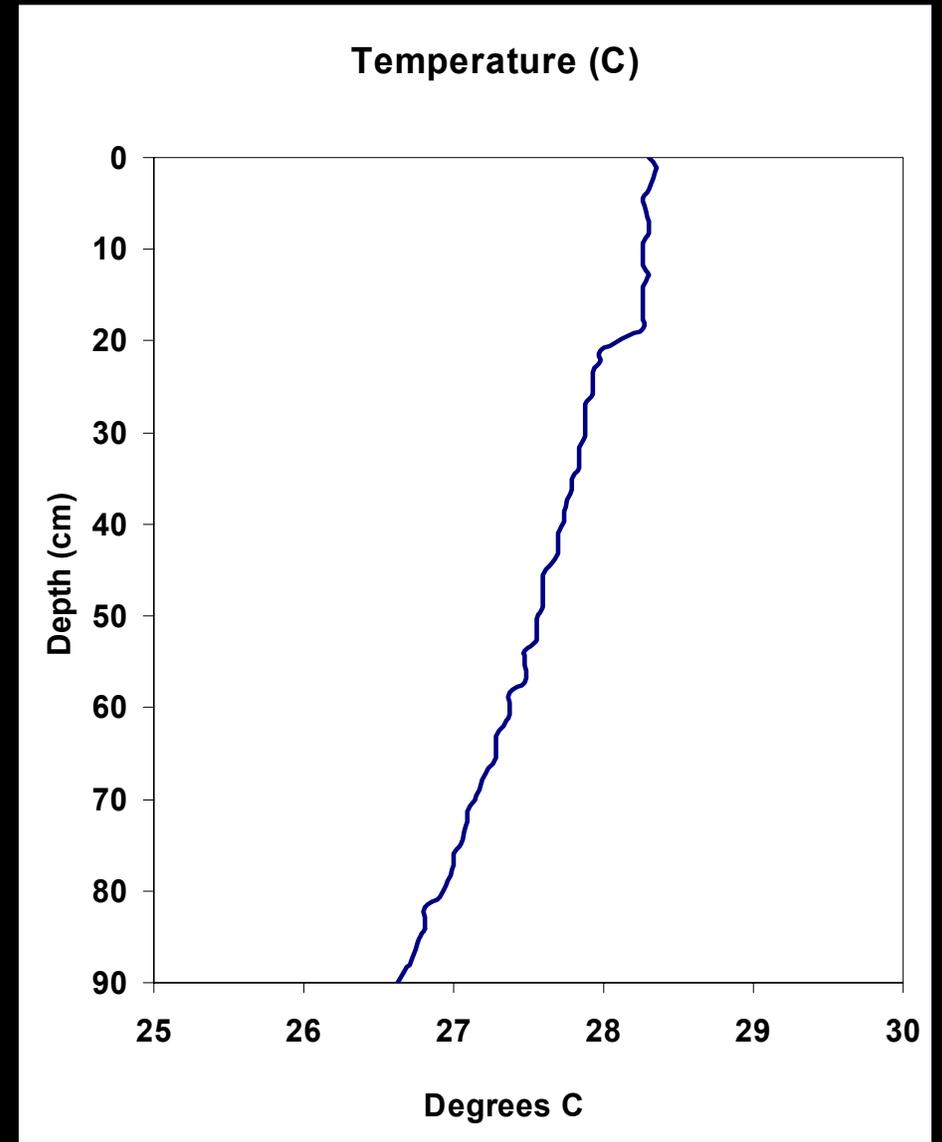
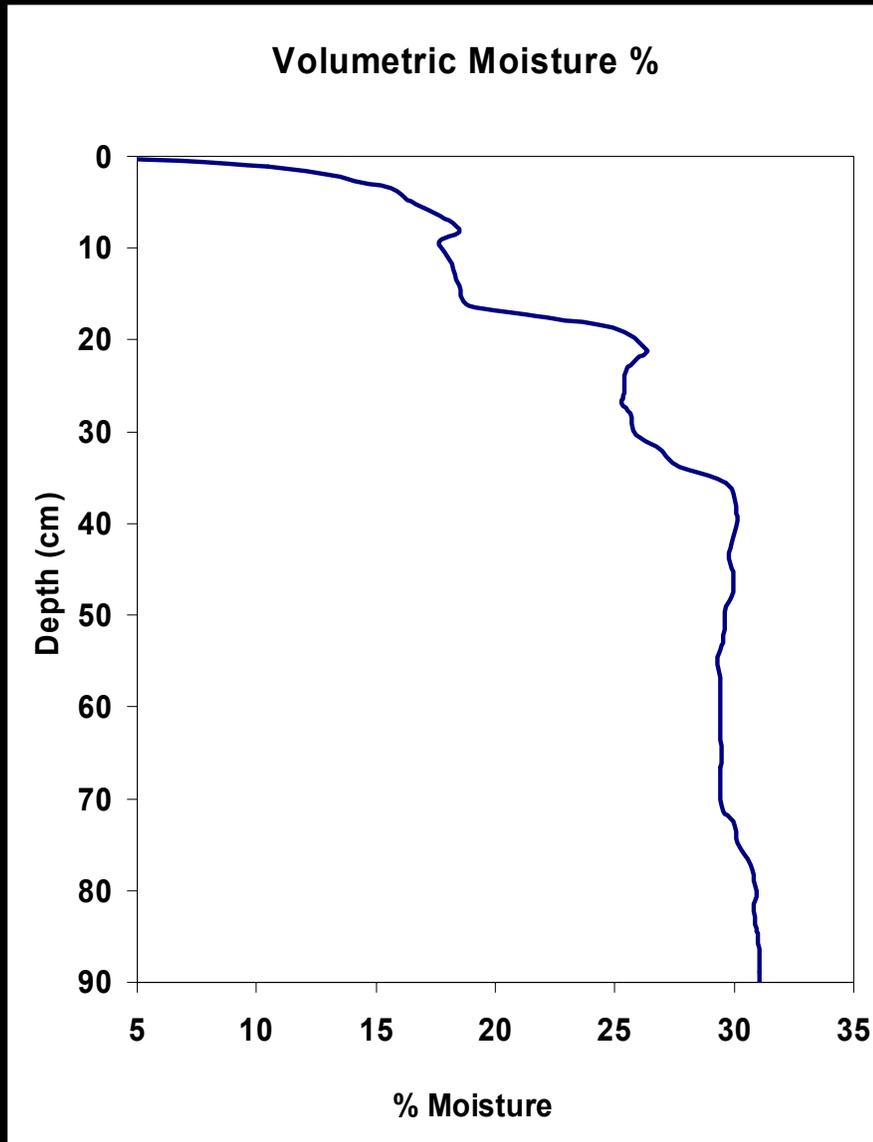
# **Compactibility of Soil Textures**

**In general, coarser textured soils have a greater soil strength than those with a smaller particle size.**

# Soil Moisture Resistivity and Temperature Probe



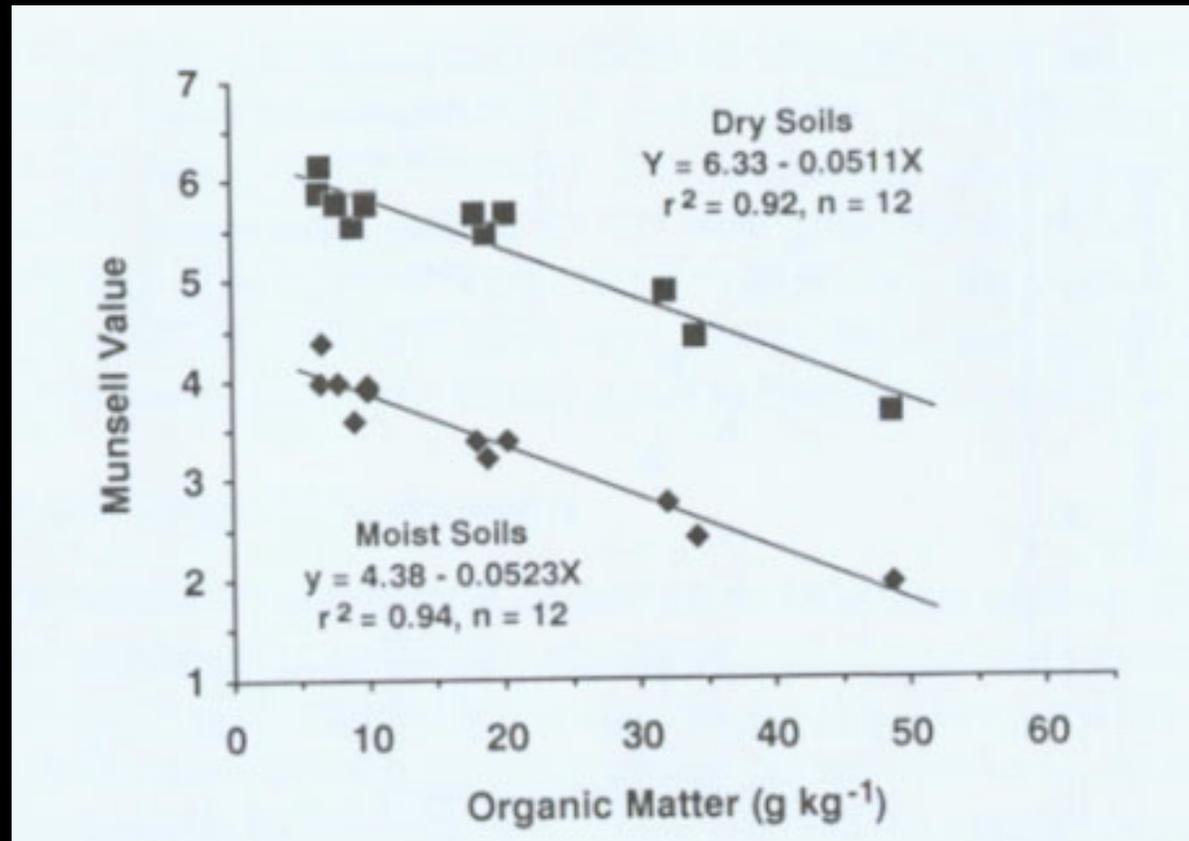
# Soil Moisture Resistivity and Temperature Probe



# Soil Color Probe

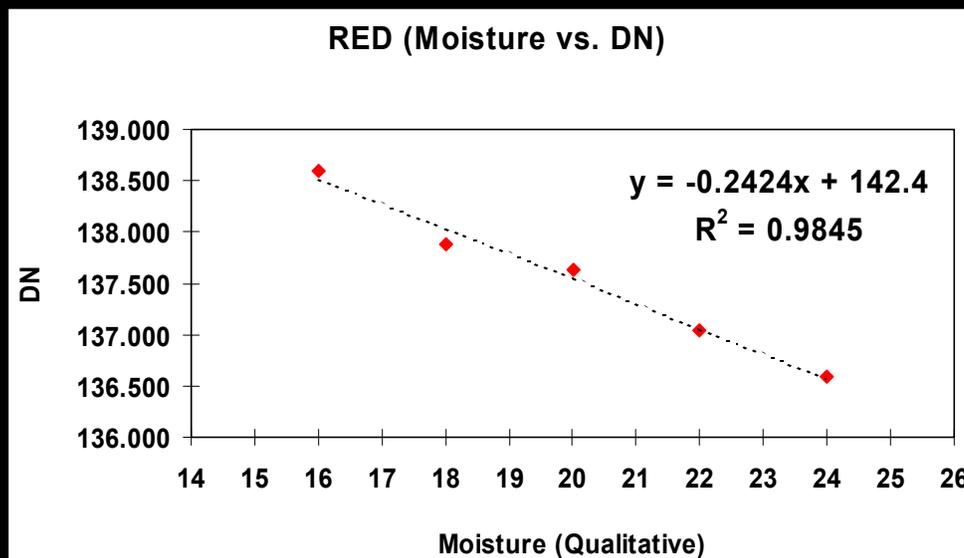
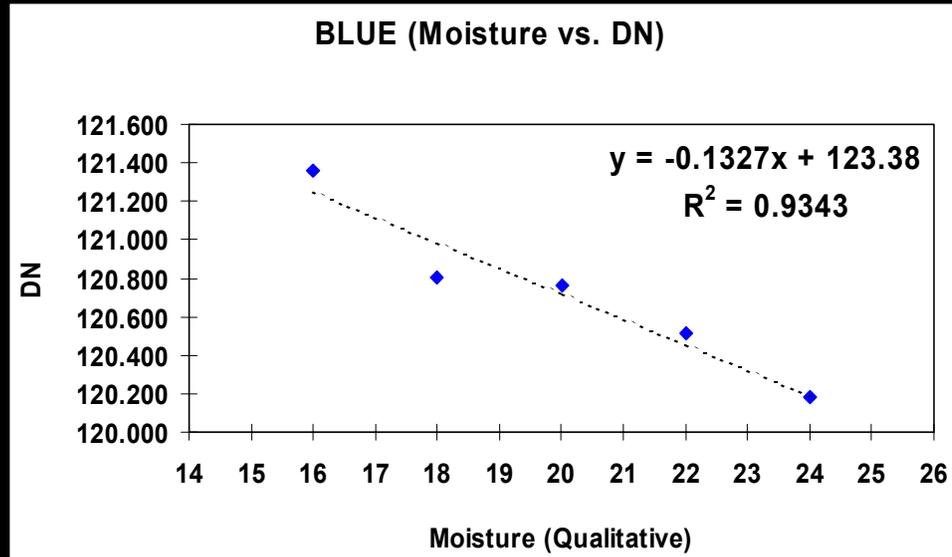


# Color vs. Organic Matter

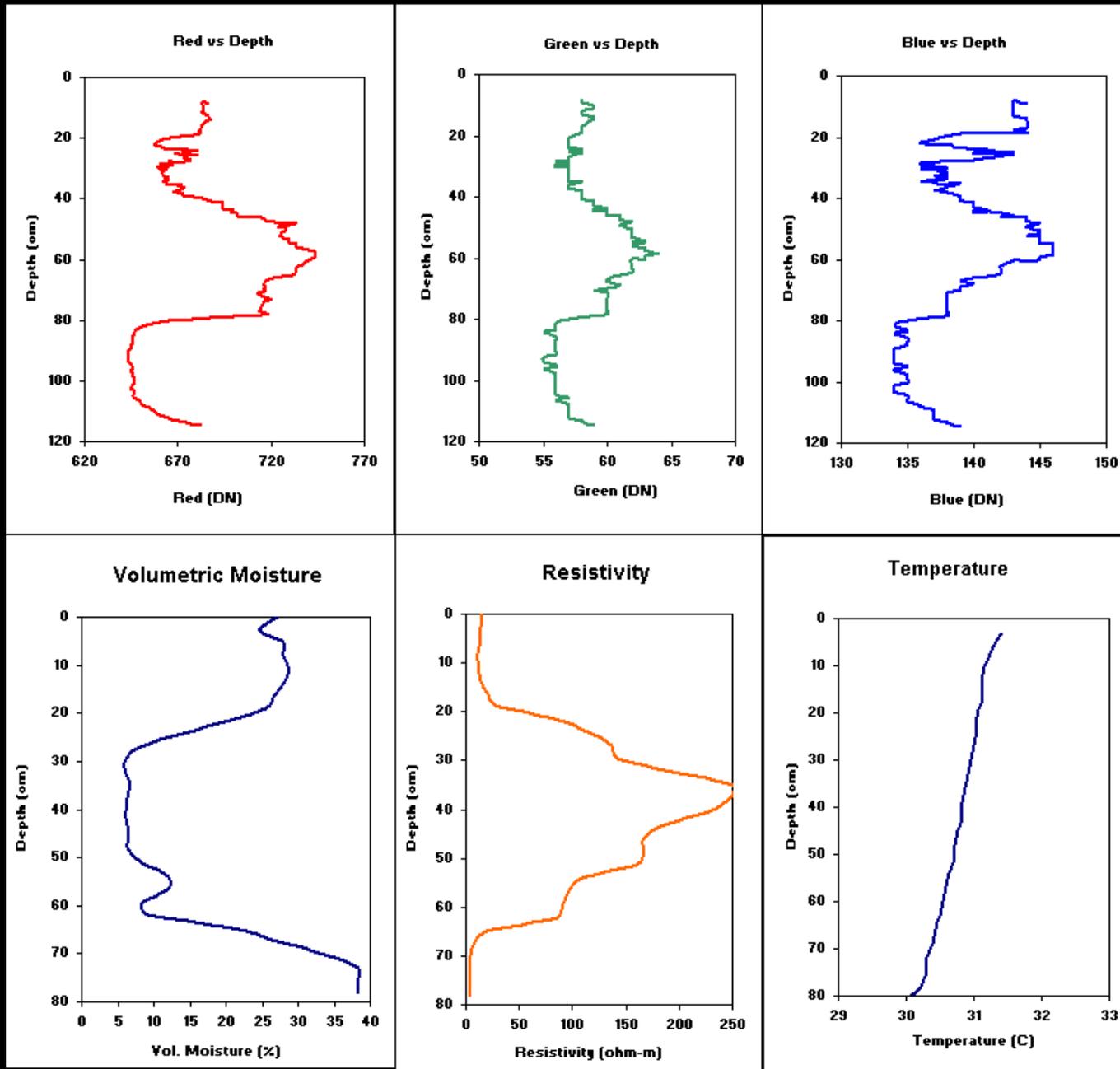


Schulze et al, 1993

# Color vs. Moisture



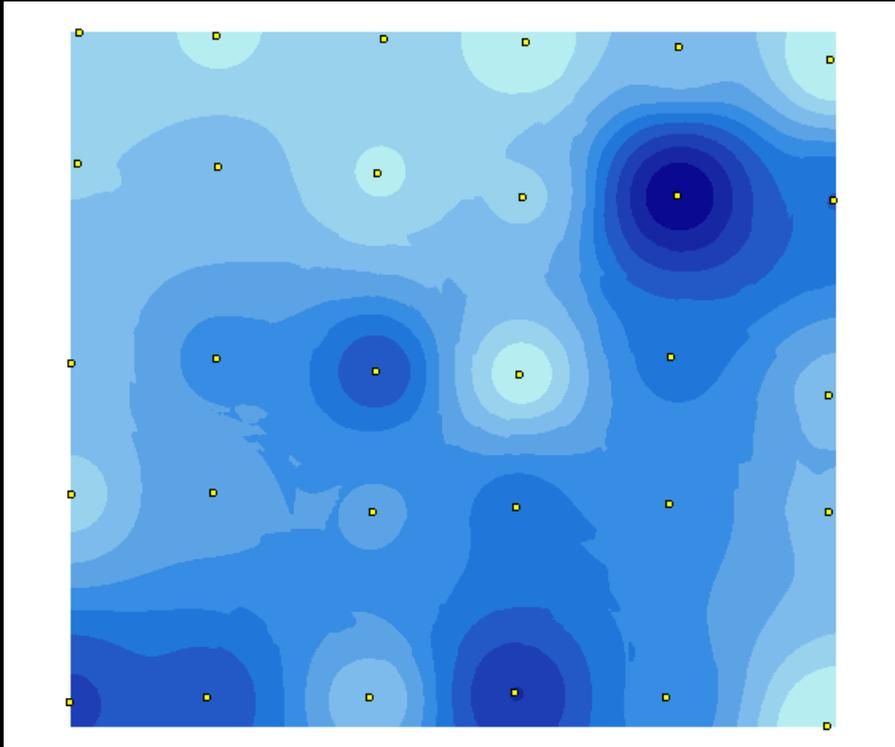
# Moisture, Resistivity, Temperature, Color



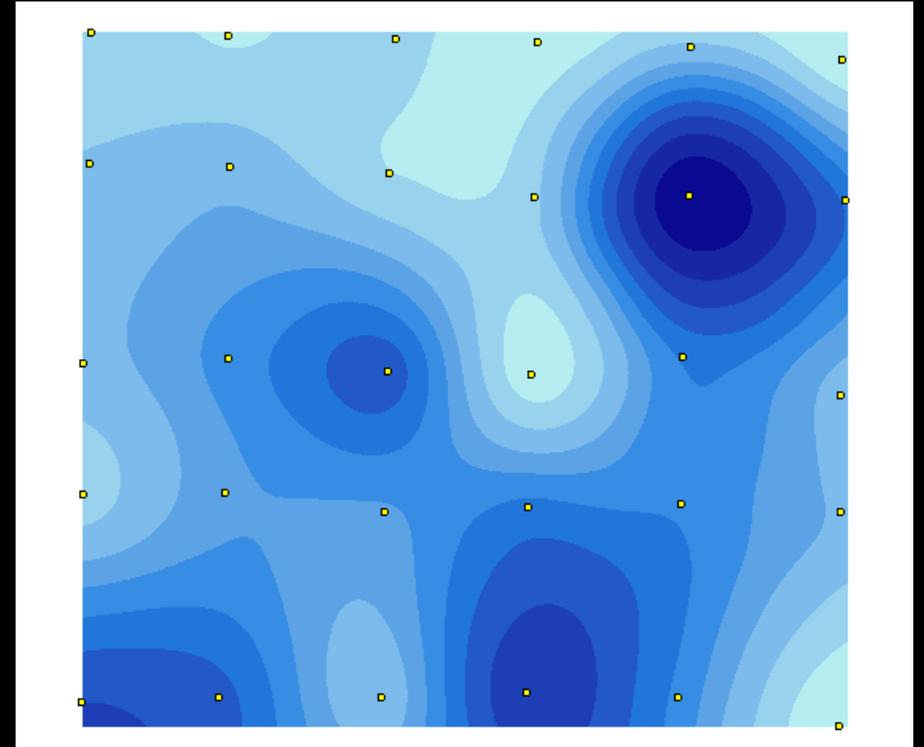
# Soil Color (Handheld) Probe



# Soil Maps



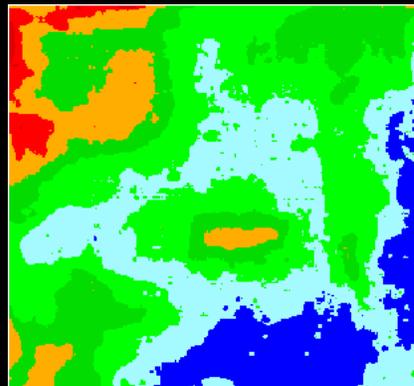
**Inverse Distance**



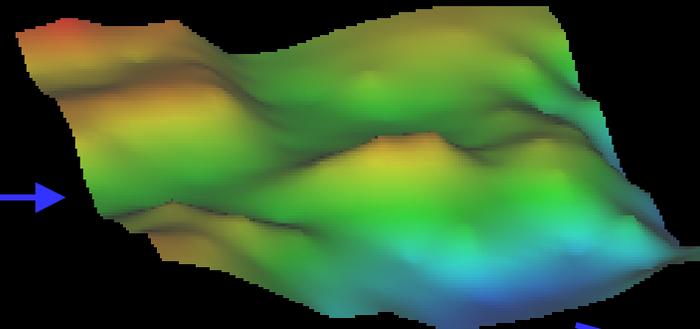
**Spline**

# 3D Soil Landscape Modeling

## Elevation (m)



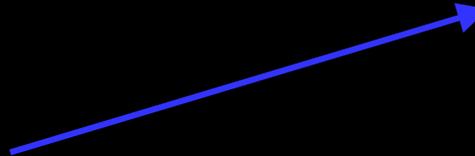
(pixel : 4m)



## Soil map units



(Data source: MUIR)

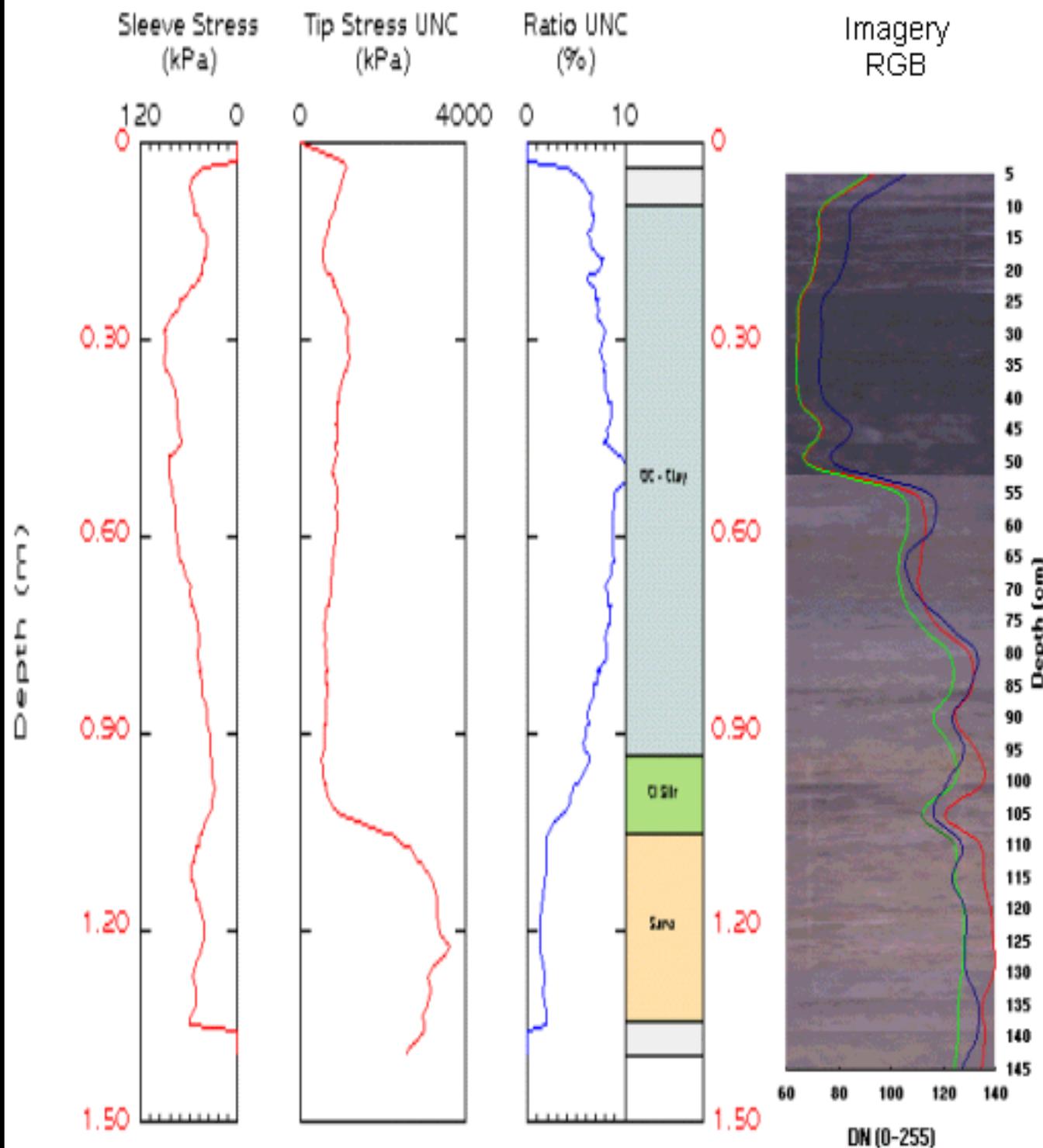


# Site: Davis Farm

Date: 22 June, 1999

Operator: DJR

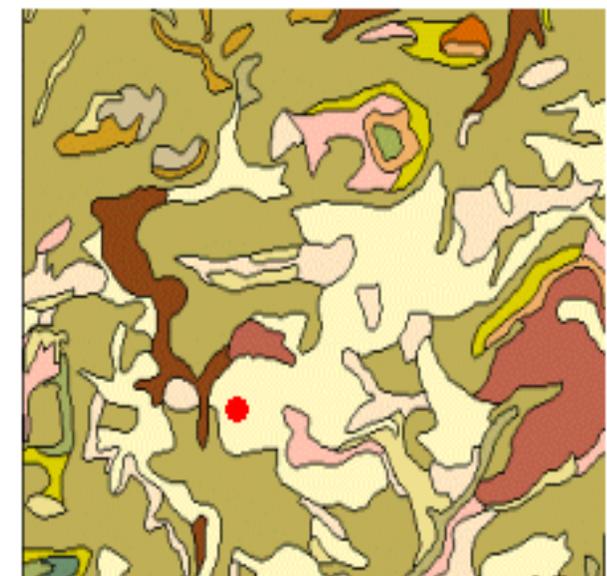
Imagery Links: [mov.](#) [jpg.](#)



## Adjacent Soil Sample Data Depth: 90 cm

Parameter	Value	Distance
O.M.	0.3 %	22 m
pH	6.7	22 m
Color	10YR 4/3	22 m
Slope	2 %	0.9 m
Texture	Sandy Loam	22 m

Latitude: -88.9094  
Longitude: 41.7443  
Elevation: 253  
Map Unit: Drummer



# Conclusions

- **SIS data:**
  - **Efficient and Effective**
  - **Digital**
  - **Repeatable**
  - **Transferable**
- **Data can be used in:**
  - **Variable rate equipment**
  - **Models**
  - **Guide for future sampling and operations**

# USDA-NRCS

## Soil Sensor Demo

June 26, 2002 - Lake Mendota Park - Madison, WI

